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THE PREHISTORIC GEOGRAPHY OF KHARGA OASIS:

A paper, read at the Evening Meeting of the Society on 9 May 1932, by

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IT is gratifying to address a Geographical Society on prehistoric archaeology. For prehistory, that strange compound of archaeology and geology, is still too often thought to be an alarming subject, comprehensible only to its own specialized disciples; and to lie in an exclusive territory of its own, out of reach from the more popular adjacent countries governed by the geographical sciences on the one side, and archaeology on the other. The time has come when those old restrictive frontiers must be revised in the interests of mutual progress; and this Society, each time it opens its doors to the discussion of a subject from over the old boundary, such as "The Prehistoric Geography of Kharga Oasis," is helping on this needed revision. It is clear that any regional geographic study would be considered incomplete if it ignored the historic past. We wish to show that it would be equally defective if it ignored the prehistoric past. Yet that is a study which receives little attention from geographers.

The work in the Kharga depression during the past two seasons, still unfinished, has been a prehistoric survey of a defined area unexplored from that point of view. It has striven to trace human history in that region from the time of man's first appearance in it; to examine the climatic conditions under which, at succeeding stages, he lived; and to synthesize both with the physiographical development of the depression. Whilst therefore the intentions of this research are ultimately archaeological and will be dealt with as such in final publication, the lines of approach have been largely geological and physiographical. Geography, geology, and archaeology, both historic and prehistoric, have been laid under contribution about equally. This paper brings into prominence the more purely geographical aspects of the results, leaving discussion of the geological and archaeological data to their own specialist publications.[1] Since however the geographical time-scale here established owes its

[1] Those already published are: E. W. Gardner, "Problems of the Pleistocene Hydrography of Kharga Oasis," *Geol. Mag.*, September 1932; G. Caton-Thompson, "Prehistoric Research Expedition Reports," *Man*, May 1931 and June 1932; "Kharga Oasis," *Antiquity*, June 1931.

existence to archaeology, it would be ungracious as well as unscientific to separate these reciprocally indebted subjects. Archaeology will efface itself as much as possible, but it will be called in now and again when needed to steady or control. Those with weak memories may find the list of prehistoric periods given towards the end of the paper a help in following the sequence of associated geographical events.

This localized work in Kharga forms part of a larger scheme begun some years ago in the Faiyum depression, 400 kilometres farther north, which seeks, by means of a series of intensive regional studies in north-east Africa outside the Nile Valley, to establish a relative chronology and a comprehensive view of man's past history within this now desert area; to assess more exactly its contribution to primitive cultural development; and to amass a body of tested data in regard to Pleistocene climatic evolution, so that North Africa may be brought into line and keep pace with inquiries of similar character now being undertaken in other parts of the world. The writers are not immune from a strong temptation to pursue this programme by means of rapid exploratory journeys into the little-known or unknown quarters of the North African desert. Such journeys are no longer difficult, must be intensely interesting, and easily achieve popular interest. But we feel that delightful, and up to a point useful, as such expeditions may be, more serious scientific need is served by intensive regional studies. Too much is overlooked through cursory methods. Even within the relatively restricted limits of Kharga we are working slowly from district to district, which explains the concentration of results, here described, into the northern half only of the depression. The southern awaits its turn.

The party has consisted of our two selves; two, or the first season three, trained Kufti workmen from the Nile Valley to act as exemplars to local labour; camel men; and for the rest we have recruited Kharga villagers, varying in numbers from two to thirty-five in accordance with the needs of the work. We avoid that pestilence of Egypt, the *rais* or headman, and keep the organization and questions of discipline and direction in our own hands. We have found the raw locals, unfamiliar with the kind of work required of them, industrious, fairly intelligent, and obedient, and definitely superior to the equivalent fellahin class in the Nile Valley. Though living at starvation's edge, with malaria rampant, the children especially seem endowed with remarkable physical endurance. We have used camel transport only, and have found it in every way preferable for our purpose to the motor trucks used in Faiyum. It takes one slowly but surely to the exact spot, and by the exact route, one wishes, permits of fixed camps in places absolutely inaccessible to any car yet made, and provides on its stately march opportunities to examine in continuous unhurried detail the terrain traversed. It is certain that the prehistoric sites found on the Libyan Plateau, during our six days' march to Kharga from the Nile Valley, would have escaped notice had not one of us, generally both, continually been scouting on the flanks of a slowly moving caravan. We were relieved also of the anxiety of dependence on cars for our water supply, while camping on the eastern scarp far from springs. The camels with their load of water-tanks plodded stolidly backwards and forwards week after week without a hitch; one only, poor beast, through the laziness

of his badawin driver, drank long and deep of a spring of Epsom Salts and died. Yet even then, a camel is more easily replaced than a differential.

Extremes met however in our work. Through Lady Bailey's enterprising co-operation we have been enabled to investigate the entire region, depression and surrounding desert, from the air, gaining a comprehensive impression of the whole, which brought into focus the mass of detailed field observation.[1] The Egyptian Department of Antiquities' concession for both Kharga and Bahariya oases is held by the Royal Anthropological Institute under whose aegis the work is performed. Financially it has been indebted to generous grants from the Percy Sladen Trustees and the British Association, to Newnham College, to numerous museums, British and foreign, and to a cementing matrix of private subscriptions.

The Libyan Plateau

Though Kharga is easily reached from the Nile Valley by a narrow-gauge railway which runs in each direction once a week, we preferred our first season to reach it on foot from Abydos, where the expedition had assembled, in order to explore at leisure the intervening 140 kilometres of Libyan Plateau and note, if possible, evidences and dates of contact between Egypt and its dependent oasis in past ages. For the history of Kharga, outlined in the next section, is strangely little known. While marching southward along the desert edge from Abydos on our way to the pass up the steep cliffs bordering the Nile Valley, a series of tufas, clays, and sands were noted for comparison with the celebrated tufas of the Kharga scarp. The Nile Valley deposits are probably Pliocene, and have been described by Dr. K. S. Sandford,[2] who however does not mention the occurrence of any shells in them. These, of freshwater species, we found to be abundant in the white clays underlying the tufa.

The great barren Libyan Plateau offered little scope geographically for anything but a study of the amazing effects of wind erosion (Plate 1). The Eocene limestone that forms the major part of the surface is scored and grooved into long sharp ridges and fans, or weathered into fantastic humps, interspersed with fields of "melon" formation—round flinty concretions left free on the surface by the removal of the less resistant surrounding rock. Flint also occurs sporadically in thin tabular sheets in the limestone, and these localized outcrops were, we discovered, always accompanied by a scattering of flint implements of Neolithic type, and ostrich egg debris, which became more and more abundant as the Kharga escarpment was reached. The main sites are marked K1 to K6 on folding map 1. How did these people—post-pluvial in age—live on the waterless plateau, now almost totally devoid of either animal or vegetable life? A probable answer lies in the occurrence of red loamy clay, flooring most of the numerous shallow wind-cut depressions sunk in the plateau. In origin this is almost certainly the insoluble residue of the limestone, washed into the lower-lying areas by occasional storms, and stained red by the iron abundant in the limestone itself.[3] If in Neolithic times the rainstorms were more fre-

[1] Air photographs taken during these flights were published in *Antiquity*, June 1931, and others in the *Illustrated London News*, 2 May 1931.

[2] *Quart. Journ. Geol. Society*, vol. lxxxv, 1929.

[3] Originally suggested by Beadnell, 'An Egyptian Oasis,' p. 29, and confirmed by Dr. Collet, *Ann. de Géogr.*, xxxv, pp. 538–539, who gives an analysis we quote on p. 400.

quent than they are to-day—and Kharga itself holds evidence as to that—sufficient water may have been held up by the impermeable clays and so made possible temporary camps on this now uninhabitable desert plateau.

Apart from these Neolithic tool-making sites definitely concentrated around the flint outcrops, and a promiscuous distribution of unassociated palaeoliths, the other evidences of early exploration on our line of march consisted of remarkable dumps of broken amphorae. These could often be seen from afar as patches of brick-red on the monotonous desert; and the larger ones—noted on folding map 1—consisted of accumulations of many hundreds, perhaps thousands, of jars. Similar stations are widespread in the North African deserts, and in many cases undoubtedly define the trade routes of Imperial Rome. But, though seen by almost all explorers, their exact positions, from which a study of great interest might emerge, and their period have been too seldom recorded.[1] Though usually taken to be water-dumps, there are obvious difficulties in this interpretation. There is no reason to doubt that this particular chain of stations is of Roman date. The prosperity of Kharga and Dakhla oases was, for reasons we shall examine, at its zenith in Roman and Byzantine times; impressive ruins of that age still stand lonely guard at the oasis termini, and the unsuspected extent of contemporary mining was realized in our flights, when miles of outlying foothills and desert floor alike were seen to be riddled with shallow workings, giving the ground the appearance of having been shelled. Sherds collected in field examination of mining areas, thus seen in full extent from the air, confirmed their Roman date. Alum seems most likely to be the mineral sought.[2] In any case the evidence of mines and protective buildings in the oasis, and pottery-dumps (whatever their purpose) across the desert to the Nile Valley, point to commercial activities on a big scale in classical times. It was remarkable that the Stone Age sites and the Roman stations were the only archaeological remains seen on the plateau. There was no vestige of nearly three thousand years of dynastic history we had thought to trace in broken potsherds of different periods. The explanation, then undreamt of, emerges, we believe, from the work in Kharga, and will be discussed in the final section.

On 14 December 1930, the morning of the sixth day, after a fortunate march free from the biting blast and excesses of cold or heat which often render the journey across this most desolate plateau a torment, we struck the great scarp at the head of the Wadi Refuf, the usual descent into the Kharga depression. Archaeological instinct however deflected us southwards, keeping to the

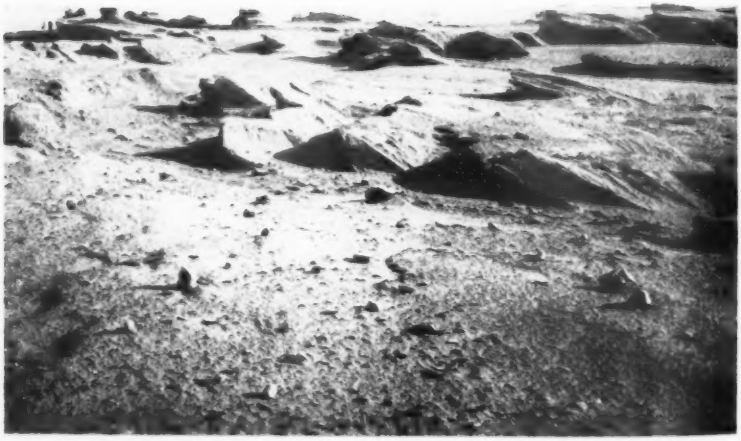
[1]The great dump described by Dr. Ball in lat. 24° 26′ 27″, long. 27° 38′ 54″ (*Geogr. J.*, August 1927, p. 122), is one of particular interest. He was good enough to give us the position of another noted on Prince Kemal ed Din's journeys in lat. 29° 43′ 56″, long. 30° 30′ 54″, north of the Faiyum scarp; this we visited in 1927, finding the way without error by dead-reckoning from our Faiyum camp. The jars were of late Roman date, and the site seems to have been a stage in a Lower Egypt–Wadi Rayan–Bahariya caravan route; we found other links at the west end of Birket Qarun and in the Wadi Rayan.

[2]A conclusion reached by Mr. Beadnell, who examined workings in the Gebel Tarif ('An Egyptian Oasis,' pp. 222–223). These mining areas of classical times must not be confused with the flint-mining areas of prehistoric times we discovered and refer to on p. 397.

1. The Libyan Plateau: wind-scoring on limestone

2. Abu Sighawal pass: view over depression with jointed limestone cliff

3. Detail of loess-like butte



4. Buttes of loess-like material, Sherika district

plateau edge: an instinct justified, for we made first acquaintance, renewed closely later, with a prehistoric paradise, before necessity drove us, two days later, to descend by the Abu Sighawal Pass into the depression to water.

The view in Plate 2 from the head of the Abu Sighawal, looking down over the depression over 350 metres below, shows a scene rivalling the Libyan Plateau in sterile desolation. A chaotic world of desert foothills, promontories, and bays, cut by a maze of valleys, lies below—a thick inner lining, so to speak, to the cliffs of the scarp proper—amongst which the eye discerns sheets of mahogany coloured gravels, and in places the irregular masses of a dark lava-like rock, which, on closer inspection, proves to be, not volcanic, but the famous water-laid tufa deposits. Far away however, a day's march distant, smudges of green bore witness to the little oases, fertile patches which dot the centre of the depression floor.

The History of Kharga

A reference to the history of Kharga might be thought to be outside the scope of a paper on prehistoric geography, but here no less than in the Faiyum we find the two subjects inseparable. In common with the other Libyan oases little of positive value is known of the history of Kharga in dynastic times, and we are unable for physiographical reasons to share an impression, based on scanty hieroglyphic allusions, of close relations between them and the Nile Valley in dynastic times. A stela in Berlin of the XIIth dynasty (2000–1788 B.C.) indicates that the Egyptians were masters of the "oasis dwellers."[1] In the XVIIIth dynasty (1580–1350 B.C.) they are similarly believed to have been subservient to the pharaohs.[2] In the XXIst dynasty (1090–1085 B.C.) one of the oases was a place of banishment,[3] and in the succeeding dynasty (945–745 B.C.) Sheshonk I installed a Libyan governor in the Great Oasis.[4] But in spite of all this no concrete remains of any kind have, as far as we know, been found either by ourselves or others in Kharga earlier than the XXVIIth dynasty, founded by the Persian conqueror Cambyses in 525 B.C.,[5] whose successor, Darius the Great, built there a fine temple still standing. In the adjoining oasis of Dakhla however (bracketed with Kharga as the Great Oasis by classical writers) two pre-Persian stelae were found at Mut,[6] and one of these dates certainly to the reign of Sheshonk I (*circa* 945–924 B.C.) of the XXIInd dynasty.

From Persian up till Byzantine times the importance of Kharga is unquestionable, judging by its fine ruins[7] and big settlement mounds, its mines, the

[1]Breasted, 'History of Egypt,' p. 182. "While the Pharaoh (*i.e.* Sesostris I) was not yet able to take possession of them, it is evident that he was in communication with their towns."

[2]*Idem*, p. 305. "Thutmose is also found in possession of the entire oasis-region on the west of Egypt. . . . The oasis-region remained an appendage of the lords of Thinis and became famous for its fine wines." Ascherson found in 1876 a stela in Bahariya, which has been attributed to Thutmose II.

[3]*Idem*, p. 524.

[4]*Idem*, p. 530.

[5]Whose ill-fated military expedition to Siwa overwhelmed in a sandstorm is believed to have started from Kharga ('Herodotus,' Bk. III, 25, 26).

[6]By Captain (Sir Henry) Lyons, in 1894, now in the Ashmolean.

[7]We published photographs of Qasr Gib and Deir el Ghennihma in *Antiquity*, June 1931; and Qasr Lebakha in *Illustrated London News*, 2 May 1931.

great extent of ancient cultivation so well seen from the air[1]; and, controlling all these activities, its elaborate system of water supply, without which no habitation on a level higher than that of scattered semi-nomadic badawins would be possible. This last is the cardinal fact upon which we pivot our conceptions of the history of Kharga depression, and base our interpretation of the remarkable absence of pre-Persian remains.

The Features of the Oasis Depression

The great depression of Kharga, the "Outer" oasis, hollowed to a depth of about 350–400 metres below the level of the Libyan Plateau in which it lies, is situated about 150 kilometres west of the Nile Valley, between latitudes 24° and 26° N.[2] Its exact area is difficult to define, for on the west and south it has no natural boundaries comparable with the steep escarpment which frames it on the north and east. Taking however the most southerly well as one limit and the broken continuation-belt of the Mohariq sand-dunes on the west, which separate it from its sister oasis of Dakhla—the "Inner" oasis—as the other, we may say that Kharga depression is a relatively narrow trough, 185 kilometres long,[3] and from 15 to 30 kilometres broad, except where the north-western scarp swings out westwards, and forms a deep bay, increasing the width to about 80 kilometres at this one spot.

Less than 1 per cent. of this great hollow, touching sea-level in its lowest basin, now supports life; and the relatively fertile patches, fractions of the 1 per cent., each separated from the next by tracts of desert, owe their existence solely to sunk wells, the waters of which are neatly canalized and led away to irrigate plots of cereals and date-palms upon which a poverty-stricken population of about eight thousand mainly subsists. The existence of these cultivated areas is precarious, for the trough of the depression is ribbed with belts of sand-dunes of "barchan" type, which engulf all which stands in their relentless progress down-wind southwards. Kharga village itself however, the seat of the Egyptian Governor of the Western Oases, and a post of the Frontiers Districts Administration, is protected considerably on the north-west by the massif of the Gebel Tarif, which stands directly on the line of the Abu Mohariq, and acts as a disorganizing sandbreak on that formidable dune-belt. The effect of this titanic encounter viewed from the air is impressive. The sand-dunes charge in never-ending waves the great stream-lined rock barrier 350 metres in height standing in their way; are repulsed, reform, and now, in broken order, pour over the defences, and stream in parallel rivers along deep longitudinal defiles of their own erosive creation. Though not arrested, their collective force is dispersed, and the "barchan" regimental formation definitely broken. Honours are easy in the conflict, though ultimately, if present desert conditions endure long enough, the Gebel Tarif will be worn down to a mere stump.

Sand-swamped Roman wells, channels, and the fields they once watered

[1] *Antiquity*, *idem*, figs. 1, 2, and 6.

[2] The topography has been so admirably described by Dr. Ball in the 'Geological Survey Report' on Kharga in 1899, and by Mr. Beadnell in 'An Egyptian Oasis,' 1909, that only the features relevant to our field work will be here touched upon.

[3] Certainly not 185 miles, as given by Baedeker (1929 Ed.).

were passed incessantly during our exploratory survey of the uninhabited northern regions of the depression. The date of the oncoming of these devastating dunes across the Libyan Desert has been the subject of much speculation and no little uncertainty.[1] Prehistoric research now enables us to give a pretty close answer.

Despite the discouraging conditions under which all life survives, the bank-linings of the little modern water-channels, often rippling their way across miles of desert to irrigate lowlying basins, are charming green ribbons. One can stand astride them, each foot in desert, and watch the activities of the birds and dragonflies which haunt them. Their flora has been studied by botanists, but maidenhair fern (*Adiantum capillus veneris*) found flourishing in a remote channel near Qasr Zaiyan was a surprising and apparently new discovery.[2] Rainfall in Kharga is rare, years sometimes passing between one fall and another. The rare event however coincided with our first winter, 1930–1931, and rain fell on two days, the largest fall happening on the night of 14 January 1931, when we were camped on the Gebel Kharran; a violent thunderstorm enlivened the night, and the desert flickered with tongues of lightning licking along the dune crests. On the other occasion work was stopped by a driving drizzle.

Wind is the curse of the oasis: it blows from the prevailing north or north-west with maddening persistency, and little modification is needed, in our experience, of Mr. Beadnell's observation that only one day in ten or eleven is calm and that on one day in three the wind attains a velocity sufficient to carry sand in suspension.[3] We have however escaped serious sandstorms. The worst, swift and terrible while it lasted, but of short duration, swept down upon us on 28 December 1930, when we were camped, defenceless, in shelterless desert in the extreme north of the depression. From Qasr Lebakha we had marched in stifling sultry heat to Qasr Gib, both deserted Roman fortresses, and then on over villainous soft going, northwards, to pitch an exhausted camp in a wilderness of exposed sandy ground. Panting for air, we ate our evening meal outside a tent, the temperature, long after sunset, in the high eighties. Before midnight a distant murmur in the north broke the unholy stillness; outside it was inky night, the stars screened off by some ominous pall of darkness in the skies: the murmur approached, and as it drew nearer it grew to a rushing sound. Even then not a tent-rope stirred in the calm still enveloping us. But not for many seconds. The storm struck us like some cyclonic wave, a wave of sand instead of water, and thereafter we had a blind battle with the elements, deprived of sight and almost of breath, in the endeavour to keep standing the two surviving tents which had not been flung down in the first impact.

[1] Beadnell, "The Sand-dunes of the Libyan Desert," *Geogr. J.*, vol. 35, April 1910, put forward the view, since confirmed by Ball and others, that the sand is derived from the arenaceous beds of the Qattara depression region. Ball observed in "Problems of the Libyan Desert," *Geogr. J.*, September 1927, p. 124, that, given a rate of progress of 10 metres per annum down-wind, the Abu Mohariq belt, about 350 kilometres long, must have taken some 35,000 years to attain its present length. This period is longer than that needed to accommodate the prehistoric culture data set out with tentative dates on p. 404.

[2] Though abundant in Bahariya (see 'Baharia Oasis,' by J. Ball and H. J. L. Beadnell, 1903, p. 15).

[3] *Idem*, pp. 198–199.

The diurnal variations of temperature are great, but in the winter months the explorer undoubtedly suffers on the whole more from cold than from heat. It is erroneously believed that frost, not uncommon on the Libyan Plateau, is unknown in the oasis; but we found that the ice which encased our water-bottle at dawn on 9 February 1932 was not unknown to the local men with us, who had certainly never been out of the oasis.

The Period and Origin of the Oasis Formation

Kharga Oasis is one of that series of depressions sunk in the Libyan Plateau which are generally believed to owe their origin mainly to wind-action in areas of favourable geological structure, and upon strata of differential resistance to its erosive power. Periodically however other agencies are suggested to account for them, and of these the work of rivers is most frequently invoked. This fluviatile hypothesis has been advanced on two occasions in recent years, by Drs. Sandford and Arkell[1] for the Faiyum depression, and by Professor Collet for Kharga.[2] It will therefore be well to prelude the account of the physiographic development of Kharga by restating the evidence of its origin.

Like the other depressions, Kharga is partially bounded by steep scarps; these occur on the east and north. To the south and west there is instead a gradual slope up to the general level of the Libyan Plateau. The average level of the eastern scarp is 400 metres; the average level of the floor about 70 metres; while the lowest points barely exceed sea-level. The rocks capping the plateau on the east and north are hard crystalline Eocene limestones, underlain by a soft series of alternating shales and marls of Cretaceous age, which pass down into clays and sandstones. The whole series has a low but pronounced easterly dip, and there is no doubt that this dip, together with the differential hardness of the rocks, has largely controlled the character of the physical development. As Mr. Beadnell has pointed out, there is no reason to suppose that the depression is due to faulting; yet a pronounced fracture or monoclinal fold, running north and south through Kharga village, has in all probability controlled the agents of erosion and helped them to work along this axis.

Let us now consider the possibility of rivers being the main agent in this work. The suggestion has been made[3] that the Abu Mohariq dune-line, 350 kilometres in length, running from north of Bahariya to Kharga, follows a pre-existing depression, which represents an old river channel; and further that this was once the course of the primeval Nile. Dr. Ball, in his paper on "Problems of the Libyan Desert," examined in the light of his unrivalled knowledge of all the factors involved the possibility of a river in geologically recent times flowing through the Libyan Desert, and emphatically rejected the view. "A study of the contoured map seems to me to be absolutely conclusive on the question at issue, for it indicates clearly that at no time within the geologically recent period can there have been any such continuous channel as has been supposed."[4] Dr. Ball would seem indeed to have disposed of the fluviatile hypothesis in general so completely that we may content ourselves

[1] "Paleolithic Man on the Nile–Faiyum Divide."
[2] *Annales de Géographie*, xxxv, 1926.
[3] Collet, *idem*, p. 534.
[4] *Geogr. J.*, July 1927.

with a few observations upon it only as it affects Kharga in particular. The elongated shape of the depression can be fitted into it, and that seems to be the beginning and the end of any evidence in its favour. There are, for example, no gravels on the edge of the boundary scarp, though they are well developed at a high level on the plateau edge overlooking the Nile Valley. The gravels that do occur in the depression are entirely of local origin, and the total absence of any foreign constituents, Nilotic or otherwise, in them is in itself almost enough to invalidate the hypothesis. No exponent of the fluviatile hypothesis has yet offered any explanation how rivers can hollow out great enclosed or semi-enclosed basins, nor how, even if thus formed, they remained more or less empty hollows, and were not gradually levelled up by deposition. Until some explanation acceptable as scientific evidence is adduced, based on more than cursory acquaintance with the areas in question, we are unable to envisage the possibility of river-scour creating the two depressions of Faiyum and Kharga.

So far as is known two agencies only are capable of the type of erosion in question—ice and wind. In this latitude, 25° N., as soon as the present planetary circulation had been established, desert or sub-desert conditions would, we consider, probably be normal to the area even in Pleistocene pluvial times. We therefore regard wind as the main erosive agent, assisted however within limits specified in this paper by rain water. But let us make it clear that this primary wind erosion we advocate, should that ultimately be proved the agent, was accomplished away back in Tertiary times, and has nothing whatever to do with the late Pleistocene cycle of desert conditions which began soon after the Aterian period in Upper Palaeolithic times, and which still holds sway. The work of vertical erosion was indeed finished at the dawn of the Pleistocene, if not before, and Quaternary man looked out from the eastern scarp over a depression as deep and broad as it is to-day. Apart from converging lines of physiographic evidence the final proof of this assertion lies in the discovery, on the floor of the depression, of Pleistocene springs, dated by workshops of Lower Palaeolithic flint tools in, or beneath, their deposits. Kharga was eroded to its present depth by Acheulean times; and the old arguments centred around the part played by water in the creation of the depression, as evidenced by the tufa deposits on the cliffs, are now finally out of court,[1] for we have found conclusive evidence that the date of these water-laid deposits, with one known exception, are of Acheulean and post-Acheulean age, and the climatic conditions which gave rise to them can therefore have contributed nothing whatever to the formation of the pre-existing depression.

The whole question needs to be freed from confused association with Quaternary variations of climate—pluvials and interpluvials—with which it has nothing whatever to do. It would seem to be purely a Tertiary climatic

[1]For instance, Collet, *op. cit.*, follows Blanckenhorn into this cul-de-sac. "Blanckenhorn tient compte des tufs, comme ceux que nous avons rencontrés dans le Wadi Refuf, qui prouvent une période d'une certaine humidité, ce qui l'amène à attribuer a l'eau un rôle important dans la formation des dépressions." And he adds: "En resumé ce que j'ai vu de la dépression Kharga–Dakhla me fait croire que Blanckenhorn a raison de faire intervenir le rôle de l'eau dans la formation des dépressions du desert libique avant l'action de l'érosion éolienne. Je vais peut-être plus loin que lui en estimant qu'il faudrait rechercher les anciens cours du Nil. . . ."

question, whose extreme upper limit may possibly extend into the Plio-Pleistocene. And in this connection two deposits only, referred to more fully in the section on physiographic development, are of sufficient age to be perhaps just admissible as fragments of evidence for climatic conditions in pre- or very early Pleistocene times; namely a massive tufa which at latest may be Plio-Pleistocene, and indicates, within the limits to be outlined shortly, a moister climate; and later than the tufa, but still pre-Acheulean, a thick breccia deposit, showing no water-action, and obviously formed in arid conditions. Either of these, or both—the moist and the dry—*may* have been laid down before the depression attained its present depth; we have no data; but both are certainly too late to be regarded as evidence for the climatic conditions conducive to the creation of oasis depressions. Moreover it is pertinent to remark that the climatic conditions which gave rise to this earliest of all tufas we have found were not intense, for it is extremely localized and the water that produced it can have played no real part in depression-scour.

Since its uplift from the sea-floor the great Eocene scarp has been retreating northwards, and undoubtedly this process has been helped at times by storm-waters, witnessed by the wadis that furrow its edge. These have doubtless assisted in a process of enlarging the cliff boundaries—horizontal erosion; but there is no evidence that these local waters ever united into anything that could be called a river, and they were certainly not accessories in hollowing out, by vertical erosion, the great basins we now know as the oases of the Libyan Desert, even were our evidence for their later date not so conclusive as it is. The question of the existence of pre-Pliocene rivers is another matter into which we do not propose to enter here, except to remark that we have seen nothing on those parts of the plateau known to us which would indicate their presence.

The Water Supply

The water supply of the depression is artesian and is derived from the great water-bearing sandstone sheet which underlies the Libyan Desert. The Geological Survey of Egypt has shown that Kharga has two water-bearing sandstones, whose relation to the floor of the depression is shown in Fig. 1. These beds have a gentle rise to the south-west, and it has been established practically without doubt, first by Zittel, and then by Dr. Ball, that their saturation occurs in their outcrop area in northern equatorial regions in the direction of the Chad Basin. This fact is of fundamental importance in our Kharga inquiry, for it seems theoretically tenable that climatic variations, pluvials and inter-pluvials, in these distant regions would eventually be registered in the Libyan oases by fluctuations of pressure in the connected water-bearing strata. A test of the practical validity of the theory will be found in the next section. The lower bed, the Artesian-Water Sandstone, which forms the supply of the oasis, 120 metres in known thickness, in no place comes nearer the surface, even in the deep trough of Kharga, than 80 metres. It can therefore only be tapped by deep bores. There are said to be about 230 wells in the oasis, giving a daily discharge of over 11,000,000 gallons.[1] The majority of these are pre-Arab in date, though who first so brilliantly discovered and exploited the deep sub-

[1] Beadnell, *op. cit.*, chap. x.

terranean supply has remained unknown. For reasons discussed later we shall suggest the Persians. Certain is it that in Roman times hydraulic engineering skill had full play in Kharga, for important settlements of that age, now reverted to desert, lend an ever-recurring interest to journeys in the now uninhabited outlying parts of the depression. The upper bed, the Surface-Water Sandstone, separated from the artesian bed by 45 metres of impermeable grey shales, actually outcrops on the floor of the depression and at the foot of the northern scarps. But this upper bed is moribund, and practically waterless, and at the present day water from it seeps out only in a few tectonically favourable spots, and lies in small stagnant pools.

In classical times, with the development of trade between the Great Oasis and the Rif, outpost strongholds were built in the mining areas and to control caravans, who would water, doubtless, at such places for a last time before their long cross-desert journeys. Some of these stations, particularly those in remote positions near the foot of the scarp, supplemented ingeniously their difficult water supply by the construction of remarkable subterranean rock-cut aqueducts, many of considerable length and depth, designed with great hydraulic skill to exploit the scanty yield of the Surface-Water Sandstone bed

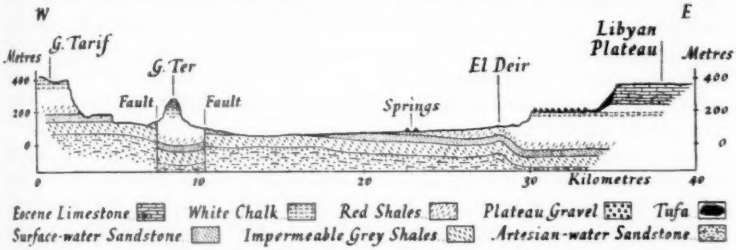


Fig. 1. Cross-section of water-bearing beds (adapted from Beadnell)

by capture and subterranean canalization of the seepage from fissures traversed by the tunnels.[1] But, short of this high endeavour to utilize every available drop from every available source—an endeavour limited to the few centuries on each side of the Christian era, and probably to be credited in the first place to the Persian conquerors, who have left remains of similar aqueducts in their own home-land—it is true to say that the Surface-Water Sandstone bed of Kharga is ruled out as a practicable water supply. This being so, the problem faced us of how to account for the presence in the oasis of prehistoric man in large numbers; for one of us during a private exploratory visit in 1928 had noted great numbers of his tools. The history of an oasis community past and present, set in one of the most waterless deserts in the world, is so vitally tied up with this question of water supply that it becomes the controlling question in all archaeological work. Since our inquiry was primarily concerned with the prehistoric periods in the oasis, our first charge was therefore to identify prehistoric man's water supply. It was plainly impossible that he should have had knowledge and equipment to tap the artesian water supply 80 metres beneath

[1]Beadnell describes these aqueducts, *op. cit.*, chap. xii. We published photographs of vertical shafts leading to these places in *Antiquity*, June 1931.

his feet; yet the only alternative supply, the surface water-bed, demands a specialized exploitation no less skilful, and equally outside the range of presumed prehistoric capacity.

The explanation seemed provided by Mr. Beadnell's hypothesis of a prehistoric and later lake, based upon the occurrence of wind-eroded residual hillocks, or "buttes," of sand-rock, which are a remarkable feature over wide areas of the depression floor, and in which he had found in some instances freshwater shells and embedded potsherds.[1] Mr. Beadnell however modified later this view and regarded them as having more likely been accumulated in an extensive marsh, into which wind-borne material was carried.[2] Dr. Collet, who stayed at Kharga for a few days in 1925 during a visit of the International Geographic Congress, agreed with this revised conclusion, but added that the deposits show a strange resemblance to certain loess of the Argentine Pampas.[3]

On our official expedition to Kharga in 1930 our first task was therefore to re-examine this question of a lake or marsh, and we spent the first weeks in a general survey of the northern half of the depression floor. We found the lake hypothesis to be untenable; no continuous sheet of water has, in our opinion, ever existed there within the vast span of man's presence in the depression. Instead, a detailed study of these curious hillocks, hitherto judged as one problem, has revealed a dual origin, widely different ages, and a distinctive topographic distribution. We propose to divide them into three groups: (*a*) Loess-like deposits apparently of early Pleistocene and locally pre-human age; (*b*) Pleistocene spring-laid deposits of Palaeolithic date; (*c*) Artesian-well deposits of ancient date.

(*a*) *Loess-like Deposits.*—The type of butte seen in Plate 4, stream-lined to the prevalent north wind and intensely eroded, but whose stumps cover miles of the depression floor, particularly north of Kharga village, is invariably devoid of the shells and human debris which, present in group (*c*), have helped formerly to confuse the issue. They are located in the lowest parts only of the depression. They may attain a height of from 4 to 6 metres. In specimens examined microscopically the quartz grains were predominantly subangular, though a small proportion were well rounded; no zircon or tourmaline[4] was seen. The grain was fine, most of it failing to pass through a 90-gauge sieve, but a considerable amount passed 60 per inch. The angularity may therefore be largely due to the smallness of the particles and need not necessarily denote water as opposed to wind-action. When the buttes rest on or near rock outcrops, a large proportion of the grains are derived rock fragments. A close-up view of a hillock (Plate 3) shows that in some there is a well-marked current-

[1]Beadnell, *op. cit.*, pp. 113–118.

[2]*Geogr. J.*, January 1911.

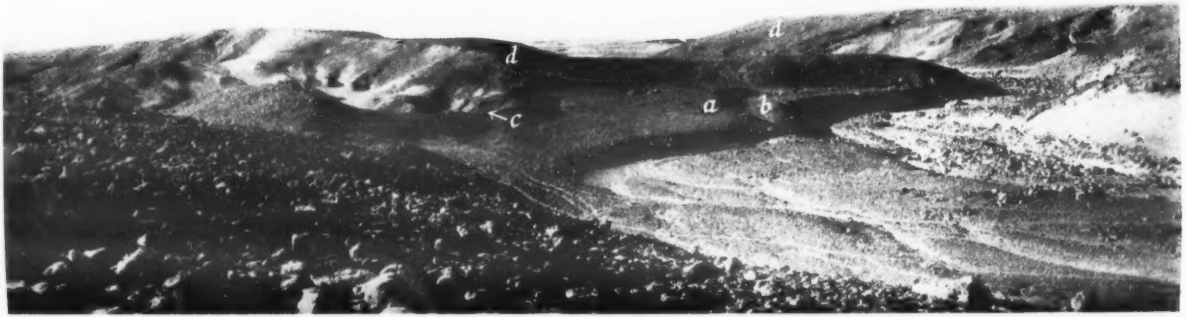
[3]Collet, *op. cit.*, p. 530.

[4]Collet, *op. cit.*, gives four analyses; but it is not quite certain, since the differential origin of the hillocks was not recognized, whether his specimens were taken from deposits of our group (*a*). In all probability they were, since his photographs show the hillocks near Kilo 180 on the railway. The total soluble constituents as given vary from 11·35 to 16·16 parts in 100; of these totals calcium and strontium carbonate vary from 5·58 to 10·40; magnesium carbonate from 3·60 to 4·25; calcium sulphate from 1·50 to 2·57; and sodium chloride from 0·06 to 0·28. The insoluble matter was mostly quartz with rare zircon and tourmaline transported by wind.

5. Gala hill: well overflow deposits of classical date

6. Exterior of fossil spring, KO 11

7. Artesian-well deposits at 'Ain Rammak



8. 'Aqaba wadi, Bulaq pass: (a) and (b) 7- and 5-metre wadi terraces, (c) headward erosion of adjacent wadi, (d) Plateau Gravel

8. 'Aqaba wadi, Bulaq pass: (a) and (b) 7- and 5-metre wadi terraces, (c) headward erosion of adjacent wadi, (d) Plateau Gravel

bedding, but this may be occasioned by wind equally as well as by water. Concretionary root-like markings are frequent, but carbonaceous layers such as one would expect to find in a lacustrine deposit—lake or marsh—are completely absent, and shells too are lacking, though, on the contrary, they are found in the other groups of hillocks we attribute to water.

To what agency, then, are these loess-like buttes due? Let us examine the possibility of a scarp-drainage origin, comparable to the playas formations of American geographers.[1] In the American desert valleys the streams coming down from the mountains deposit first their coarse material at the mouths of the canyons, then that of medium grain, and finally the finest silt and clay, which is laid down on the evaporation of the flood waters after they have reached the lowest parts of the valley. This process gives rise to nearly flat, hard surfaces fringed with chemical precipitates, generally barren of vegetation, partly on account of the salt in the soil, and partly on account of its alkalinity. These areas are known as *playas*, and they are in essentials dry lakes, which rarely contain water except during the heaviest storms.[2] They are characteristic of desert valleys, and from the nature of their formation show a zonal arrangement; the densest clay being in the centre of the flats; sand and silt on the periphery.[3] The question arises whether our deposits of group (*a*) are comparable in that the run-off from the scarp, only about 20 kilometres distant, collected in the lowest parts of the depression and formed playas. In favour of the hypothesis is the fineness of grain and the general location in the lowest parts of the oasis floor. Against it is the absence of any observed zonal arrangement, the material being, on the whole, remarkably similar over wide areas. It was seen to pass under one gravel, but was never traced into one, neither does it contain pebble layers. Further, the salts noted in Professor Collet's analysis are not found in thin horizontal layers, as would be the case if they had been deposited by solution on the evaporation of flood-waters; banding of any kind is generally lacking. Finally, the complete absence of shells is also against their being playas, for even had the waters been too saline to support life on the depression floor yet we know that at the time the great gravel spreads were being laid down on the scarp there existed numerous land and freshwater shells, some of which would certainly have been washed down in the fine silt.

The evidence on the whole, then, would seem to be against a playas origin. And if we discard the dry-lake theory, we must also discard that of a permanent lake or marsh for the same reasons. In addition, the absence of beach deposits, benches, spits, or other signs of wave action, together with the great variability of level at which the sand-rock hillocks of this group are found, all strengthen the conclusion that there was never any extensive sheet of water on the floor of the depression. How then can they be accounted for? From their location and character the most acceptable explanation would be that they are derived from the subaerially weathered material of the surrounding Cretaceous sandstones and shales, accumulated by wind in pre-existing

[1] A suggestion made in 1910 by Ellsworth Huntingdon, "The Libyan Oasis of Kharga," *Bull. Am. Geog. Soc.*, September 1910, but of which we were unaware until this paper was written. Huntingdon does not seem to have visited Kharga.

[2] Johnson, *U.S. Water-Supply Paper* 278, 1911, p. 14.

[3] Meinzer, *U.S. Water-Supply Paper* 423, 1917, pp. 42, 60.

hollows in the floor. This would be in accordance with Professor Collet's observation of their loess-like appearance, though they are probably not fine enough in grain to be regarded as true loess. We cannot directly date them, but from the events in the scarp, outlined in a later section, we conjecture that the main period of their formation synchronizes with the very arid one that marked the formation also of the breccia deposits (Plate 11). In any case they antedate gravels of Middle Palaeolithic age; indeed the preservation of the deposits from such remote times may be accounted for partly by the subsequent gravel capping which provides an upper dating limit for their age, and partly by the consolidating effects of spring and well overflows.

(*b*) *Pleistocene Spring Overflow Deposits.*—Our second group of eroded hummocks are of entirely different origin and location, and range in date from Acheulean to Aterian times, judging by the established ages of the parent springs whose overflow deposits they represent. They occur in groups of isolated wind-eroded stacks of laminated sand-rock with clay stringers, on the lower ground in the immediate vicinity of the crater-like Pleistocene springs situated on eminences above them, and whose importance necessitates a separate section. They are in lithological character and mode of formation identical with the well deposits of historic date (group (*c*)), and need not therefore in these respects be separately described. Big groups stand at the foot of the Gebel Kharran. With one dubious exception they are devoid of shells—an absence noticeable also within the parent spring-mounds, and due probably to the acidity of the spring-waters, for which there is abundant evidence. The material, when isolated by wind erosion, at first sight might be mistaken for that of the loess-like buttes. But it can in fact always be distinguished from the latter by the absence of lime.

(*c*) *Historic Well Deposits.*—The distribution of this third group of sand-rock hummocks, a typical specimen of which is shown (Plate 5), is confined to the vicinity of artesian wells and old irrigated land, where they occur on the slopes and lower ground beneath a well situated on higher ground. Primarily the product of irrigation water constantly depositing its load of silty sand, these deposits of impressive depth have been built up, in perhaps equal measure, by blown sand. In substance they are distinguished from the preceding groups by the numerous thin red clay bands, separated by layers of wind-blown sand of varying thickness. They are frequently riddled by ferruginous root-markings. The abundance in them of freshwater shells and animal bones,[1] combined with the failure to distinguish between the different origin and ages of the three superficially rather similar deposits, was the primary cause of the old lacustrine fallacy. The occurrence in them also of sherds of red pottery and segments of clay water-pipes provided a further source of error, for to accommodate these objects it was necessary to postulate a lake existing on into historic times.[2]

We visualize the deposition of these ancient well deposits somewhat as follows. An overflow of irrigation water, collecting in hollows, leads to vegetation. This in turn arrests blown sand; the level rises, roots consolidate, and the resultant deposit will continue to grow just as long as the respective levels

[1]Beadnell submitted specimens to the late Dr. Andrews, and they were pronounced to be those of two domesticated species—an equid and a bos.

[2]Beadnell, *op. cit.*, chap. viii.

of flowing well and deposit thus created directly and indirectly by it remain in equilibrium. Thereafter the story is one of unchecked erosion, and in course of centuries the old sheet of localized well deposit is cut up by the wind into the fantastic stacks yet remaining, as at Gala Hill, illustrated in Plate 5, where long-disused Roman wells cap the hill above. To an archaeologist the age of these deposits is not in doubt. The sherds in them are not older than the Persian—Ptolemaic period, and not later than the Byzantine, A.D. 600. They give a dated measure for the swift scale upon which the two most impressive agents of a desert climate operate, namely deposition and erosion.

These observations upon historic well deposits of classical date are in harmony with Mr. Beadnell's investigations of existing wells.[1] He gives instances of the amount of clay and sand built up by the process described above around 'Ain Jaja and 'Ain Dakhakhin, in the south of the oasis. He considers that when the wells were originally bored they were at plain level, while, till a few years ago, 'Ain Dakhakhin was "on the summit of an eminence which, by the slow accumulation of sand and clay, had reached a height of 30 metres above the surrounding plain." A similar state of affairs is seen in Plate 7 (taken from a photograph kindly supplied by Professor F. W. Oliver), where the modern channel has entrenched the old deposits at 'Ain Rammak, in the south of the oasis. The ancient well had ceased to flow, but was reopened by the present inhabitants. When the bore reached a depth of 30 metres, though no water was visible when work was stopped for the night, next morning a large stream was flowing from the mound, rapidly cutting through the soft soil.[2] In view of these known accumulations of well deposits we have no hesitation in attributing the early historic well deposits of our class (*c*), still standing 5 or 6 metres above the level of the surrounding desert, to the same cause, though erosion has done its best in over a thousand years of intense dissection to obscure their origin.

These deposits are of course distinct from the dredging mounds, ancient and recent, which form yet another group of hillocks, some of considerable height. These last are entirely of artificial origin, consisting of well cleanings, and there is no order in their bedding.

The Fossil Springs

So much for the lake. Its removal from the prehistoric map caused us no little embarrassment, for we had to allow prehistoric man a water supply of some kind, and for the moment could offer him no alternative. The true explanation lies elsewhere, and introduces a new discovery which henceforward will be of much importance in the prehistoric archaeology of North Africa, namely fossil or dead springs.

A detailed description of these springs with an attempt to account for their location will be found in *Geol. Mag.*, September 1932. Consequently an outline only will be given here.

A noticeable feature of certain localized areas of the depression floor are groups of crater-like mounds with concave tops of hardened sand-rock, tending to

[1] *Op. cit.*, pp. 78–79.

[2] We are indebted to Mr. O. H. Little, Director Geological Survey, Egypt, for this account.

cap ridges (Plate 6). One such mound-capped ridge, the Gebel Kharran, ½ kilometre long by about ⅓ kilometre broad, attracted our attention owing to the profusion of Palaeolithic and Neolithic flint tools upon it, concentrated more or less in the immediate vicinity of the "craters." The nature of these mounds was not apparent. We cut a trench across one of them, about 25 metres in diameter, and disclosed beneath the capping crust of hard sand-rock about 1 metre thick, an alternating series of loams, clays, and silver-white sands, which we excavated to a depth of over 9 metres, without reaching bedrock. These deposits were violently disturbed, slipped and faulted, and geology, never before confronted with anything similar, was nonplussed to explain their origin. By degrees however it became clear that they had been laid down by a spring of remote age, long since dead or "fossil." The concentration of flint implements around the base was explained; prehistoric man's mysterious water supply had been at last discovered; and with it the last vestige of need to postulate a lake dismissed.

The discovery of a flaking site of flint tools *in situ* at a depth of 1 metre in the deposits settled the age. The deposits were of late Pleistocene age, dated culturally to Aterian (early Upper Palaeolithic) times. This culture, with roots in the Middle Palaeolithic, is remarkable as being the earliest yet known in which man made arrow- or spear-heads with a definite tang; but prior to the work in Kharga, its relative position in the Palaeolithic culture-sequence (shown on p. 404) had never been satisfactorily established. The occurrence of the loam beds, containing carbonized reed-stems, and yielding also fruit stones of a wild date[1] (*Phoenix sylvestris*), now growing on the slopes of Ruwenzori and the Salt Ranges of the Punjab, suggests stages of quiescence in the spring, when the vent was occupied by a stagnant reed-fringed pool. The greatly disturbed beds of clays and white sands, flung up chaotically from the Cretaceous series below, undoubtedly represent times of great activity, when the subterranean waters, almost certainly seated in the Surface-water Sandstone now moribund, burst through the rock floor along lines of structural weakness, and discharged under very high pressure. To these more active episodes do we attribute the thick accumulations of silty deposits now surviving as buttes on low ground at the base of the main groups of Pleistocene spring-mounds, and to which we have already referred in the preceding section (p. 382) as spring overflow deposits. In this spring, as in all those subsequently investigated, the surrounding country-rock was Cretaceous clay, which plunged steeply down towards the vent.

The human episode on the edge of this fossil spring came late in its history. That it was still fairly active is however suggested by the fact that the flaking-floor within its deposits never overlapped into the area in which we localized the vent; it still kept man to its margins, and was not just a patch of damp sand where water could be got by scraping a hole. The tool-makers' floor, evidently exposed for a considerable time, as the implements are somewhat wind-worn, was finally sealed over by a deposit of sand, now consolidated sand-rock. This, under a lens, differs from the white sand of the underlying spring-laid beds, resembles modern dune-sand, and points to the oncoming of desert conditions in this latitude shortly after Aterian times. We have found these capping seals

[1]Identified by the kindness of Mrs. Clement Reid.

of sand-rock to be the invariable finale of all the fossil springs known to us. They consist in essence of drift-sand consolidated into rock under capillary action from the damp below, and consequent growth of vegetation. The deposit is, in short, an immobilized, fossil dune.

The investigation of other spring-mounds was no less fruitful of information, and, being diversified, extended considerably its range. Plate 10 shows the earlier stages of excavation of a spring similar in general characteristics, but yielding two widely different human cultures. The cross-section given in Fig. 2 shows both the complications and the interest of these deposits. The maximum depth excavated was again 9 metres. Passing through capping sand-rocks of intense hardness (capable of bending a 1-inch crowbar) which yielded in its upper levels a Neolithic industry with crude pottery, we came at about 1·70 metres to a thin seam of gravel. This gravel contained quantities of flint tools of Middle Palaeolithic type. Working westwards towards the centre we came upon a fault, marked by a smooth, greasy, clay slide. These slides, or slicken-sided surfaces, are a constantly recurring feature in all the fossil-springs we have examined, and denote, we think, not generalized earth movements, but slipping of the saturated beds under the action of differential desiccation. They render the excavation of these springs a dangerous task, for they act as well-greased shoots over which the other beds resting against them may slide at any moment. It is impossible to predict where, or at what angle they lie, or to guard against the possibility of having several hundred tons of earth slipping down on to everybody working below from some hidden slide. In this particular spring we had thirty-six men and our two selves at work, and the beds of archaeological interest, needing detailed excavation, lay at 5 metres and lower. To make matters worse, they were of cement-like hardness, and had to be removed by crowbar and sledge-hammer, setting up a most unpleasant vibration in the soft overlying deposits rent with hidden and exposed slides. The slide seen in the section (Fig. 2) has let down the beds on its other side, including the gravel seam full of tools. This is picked up again, still crowded with implements, on its down-throw side, but now at about 4 metres below the surface; and it continues its course, tilting slightly down towards the centre of the spring where we found the vent. Another thin seam of implements of similar kind lies about 50 centimetres below on bedrock of Cretaceous clay. When these two human floors reach the vent they are decapitated, and dismembered fragments were found here and there in the vent deposits. The vent, a region of chaotic deposit, we explored down to 9 metres without reaching bottom, and then we had to stop, as the danger was too great and our object had been served.

Two main physiographic facts emerge from this particular spring, both important as providing cross-evidence for our other work on the boundary scarp of the depression. The first is that a gravel bed, having its origin in the eastern scarp, had been washed down 18 kilometres out on to the floor of the depression, and that this gravel episode dates to Middle Palaeolithic times by the flint tools in it; and secondly, that this spring's first active discharge, which truncated and shattered the gravel, must be later than its deposition.

One further spring, out of many examined, merits a word. At the place our men are digging in Plate 9 no fossil spring-mound broke the plain of flat

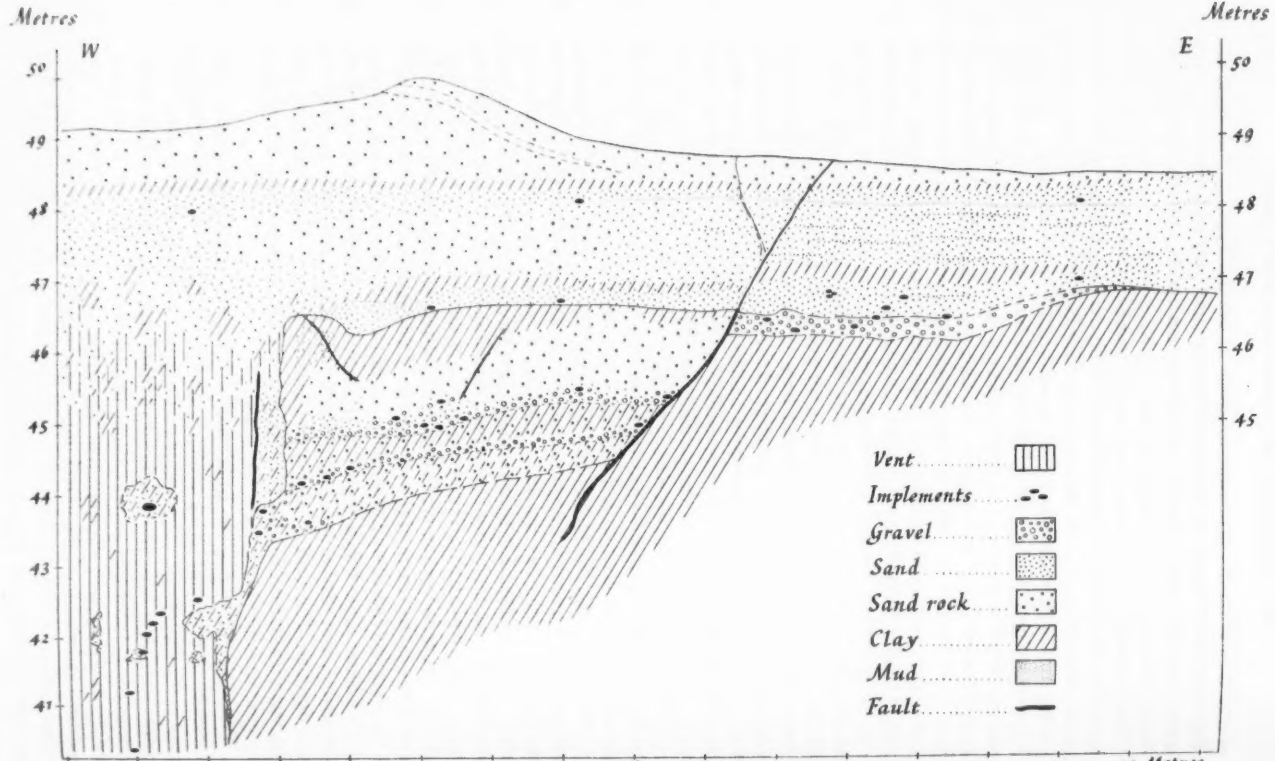


Fig. 4.—Section of Fossil Spring KQ 84.

sandy desert, stretching monotonously to the cliffs of the eastern scarp 20 kilometres away. But the spot was suspicious on account of a solitary flint tool of Acheulean age—a Lower Palaeolithic industry of far greater antiquity than anything we had hitherto discovered in Kharga. A trial trench across the spot turned up others and detailed excavation revealed a prolific floor yielding over five hundred magnificent tools of similar age.[1] They lay on comminuted and disturbed bedrock, covered by a series of spring-laid deposits characterized by evidences of violent slipping and contortion. Indeed, it was the unnatural tilt of a disturbed bed which sent just that one tool to the surface. This faulting is later than the deposition of the implements, and without question it was caused by the violent irruption of a spring in the vicinity, whose vent however in this case we failed to locate.

Our investigations therefore show that the fossil-springs were active, collectively, for the great period of time which separates the Acheulean culture-stage from the Aterian. In Europe that period is occupied, at a minimum estimate, by the last interglacial (the Riss-Würm of Alpine glaciologists), the last major glacial (the Würm glaciation), and the earlier post-glacial periods: some indeed would compress within these culture limits the last two glacials, the Riss and the Würm. What evidence have we for the date of their extinction as active sources of water supply: for their fossilization?

Fortunately the evidence, owing to prehistory, is tolerably clear. We have noted (p. 384) that the earliest dune-sand collected immediately *over* the Aterian (early Upper Palaeolithic) floor. By the time the succeeding culture, of Capsian affinities, had established itself in Kharga the grip of aridity had appreciably tightened, for we find its relics *upon* and *around*, but not *in*, as formerly, the spring deposits. Dune-sand was smothering them; and the very gradual oncoming of full-desert conditions—a process we attribute as much to gradually increasing drift of wind-borne sand into latitude 25° from its far-distant northern source, coupled with the cumulative failure of the Pleistocene springs, as to any measurable local climatic change—progressed thereafter apparently unchecked, until by Neolithic times man, after a last attempt to water himself by boring through the capping sand-rock crust sealing the dying survivors of the Pleistocene springs,[2] was finally driven away, and established himself elsewhere.[3]

By this unexpected discovery of the fossil springs we not only provided prehistoric man of Lower, Middle, and Upper Palaeolithic times with a now-vanished water supply, but introduced a new and powerful line of research in prehistoric geography, applicable to wider desert fields than Kharga alone. Their discovery proved that in late Lower Palaeolithic times the floor of the depression was eroded to its present depth; they proved that even throughout

[1] A photograph of a group *in situ* was published in *Man*, June 1932.

[2] Little bore-holes were actually identified.

[3] Certainly in the Nile Valley. Among other cultural objects of westerly origin he introduced a specialized type of oval flint axe with bevel edge, whose date and origin has puzzled all who have found it there. We traced his camping sites right across the Libyan Plateau (p. 371), and this type of axe has been found, significantly, on the low desert near Nag 'Hamadi, *i.e.* where the shortest route from Kharga strikes the Nile Valley; whilst other large collections come from settlements at Armant, near Luxor.

the so-called Pleistocene pluvial period man had recourse, not to local lake or to river, but to springs for his permanent water supply. They open out suggestive possibilities for the desert distribution of early man. With increased head of water in the equatorial regions in the pluvial periods, for which there is abundant evidence, springs deriving their supplies from thence, similar to these in Kharga, may well have gushed out in various parts of the Sahara,[1] providing not only routes of migration now closed, but supporting local settlements, whose discovery by explorers in the remotest and most arid regions has so long puzzled those who are unable to acquiesce in the belief of abundant rainfall in the Libyan Desert in Pleistocene times.

If we seek for a parallel to these springs at the present day, there can be no doubt that they are identical with the "mound" or "knoll" springs of Australia. A detailed comparison will be found in the *Geological Magazine* article alluded to, and readers interested in the subject are referred to this.

The Eastern Scarp

The geographical history of Kharga thus far established on the floor of the depression needed to be confirmed and amplified by study of a very different order of evidence in the great escarpment. Here accordingly we spent many weeks of intense interest combined with not inconsiderable physical hardship. We had touched the boundary cliffs at several points in the north-west and north-east corners during our preliminary survey, but at that time had neither intention nor organization to delay for the detailed work obviously needed. This was postponed until our second season, whereby we gained the advantage of having studied in advance great lengths of this inhospitable region from the air.

The 50-kilometre stretch of escarpment thus selected for intensive study—from south of Bulaq Pass to Refuf Pass—is of special value for more than one reason. It includes four out of the seven main passes in the eastern cliffs up which all traffic has been forced since the dawn of travel, providing a concentration of discarded goods in which the archaeologist may read the outline history of the oasis; for the 30-metre vertical and strangely jointed limestone cliff, seen in Plate 2, which crowns it, is an insuperable obstacle, surmountable only at these few spots, even were the middle and lower levels able to provide possible gradients for pack animals, which they rarely can. These middle and lower levels, projecting in places as much as 6 or 7 kilometres horizontally from the top plateau, are thrown out into a chaotic wilderness of fringing foothills, bordering great outwash plains.[2] Seen from the air the most striking features of this eastern stretch are intermittent smudges of cinder-like blackness formed by superficial sheets of calcareous tufa, water-laid deposits of a recent geological age. Though mentioned by every scientific visitor to Kharga they had never been clearly dated, and we were, for palaeo-climatic reasons, most anxious to do so. The gravels too are magnificently developed along this stretch, and their brown sheets cover miles of ground. The scarp is dis-

[1]Subject of course to obvious restrictions of level and tectonics. They certainly occur in Algeria, and, we suspect, in many other places.

[2]Photographs taken by Lady Bailey were published in *Illustrated London News*, 2 May 1931, and in *Man*, May 1931, Plate F.

9. Fossil spring of Acheulean age, KO 10

10. Deposits of fossil spring KO 8a in excavation

11. Bulaq pass: breccia pinnacle of pre-pluvial age

12. Detail of breccia pinnacle, showing angularity of components

sected by major and tributary valleys steepening to gorges in the higher levels. These provide clean-cut sections, sometimes 25 metres in height, of breccias and gigantic boulder-beds, capped by tufas and gravels (map 1, sections 1–4).

Our task was to ascertain the order of events responsible for this chaos of raw material, deposited, sorted, redeposited, resorted, slipped, faulted, and to correlate each stage, if possible, with early man. We had the field to ourselves, for no one had before approached the geology and physiography from an archaeological angle.

The Physiographical Development of the Scarp

Although the broad outline of the oasis was drawn in by the end of the Tertiary, the filling in of detail continued throughout the Pleistocene, and leads to a consideration of the physiographic development and its influence on prehistoric man. Erosion at its maximum may be studied in the eastern scarp, while the lowlying areas have acted as receiving basins for the material brought down. The motive force in this case was undoubtedly water, as opposed to the earlier predominance of wind; and this force, operating partly by degradation, partly by aggradation, very materially changed the physical features of the scarp within the "pluvial" episodes of Pleistocene times.

The gravels fall into three main groups: Plateau Gravels, which form great sheets and long flat-topped spurs, marked *d* in Plate 8, these have themselves to be subdivided in accordance with level and relative age of deposition; Terrace Gravels, which form steep-sided ridges at the base of the scarp and, concentrated near the debouchment of wadis on the plain, represent outwash sheets; and Wadi or Valley Gravels, which form double or triple linings to the valleys cut long after through the Plateau Gravels, and which are marked *a* and *b* in Plate 8. The periods of deposition of all three are now established by prehistoric evidence, which emphasizes once more the value of archaeological equipment in Pleistocene physiographic studies.

Similarly it was realized that the tufa was not a single homogeneous deposit as had been thought, but included varieties of different ages, each requiring consideration. Three out of four are now securely dated. To simplify therefore a story more complicated than had been dreamt, the series of diagrams (Figs. 3 and 4) has been constructed to illustrate graphically and serially the more striking events. Each of these is a generalization based on many sections.

1. So far as we know at present the earliest stage is one of aggradation, and is represented by a thick massive deposit of lime (Stage 1). We have named this Plateau Tufa to distinguish it from the later types which we have named Wadi Tufas. This tufa or travertine always lies at a high level and is characterized by its hardness and by the blue-black colour of its weathered surface.[1] It appears, in contrast with the later tufas, to lie always directly on the country rock. At Bulaq Pass, where it is best developed (folding map 3), it lies at a height of 370 metres, separated by a longitudinal valley half a kilometre in width from the Eocene scarp at 384 metres. At the time of its formation however it must have been joined to the Libyan Plateau—a deduction based on the presence of crystalline limestone pebbles on its surface. It is probable that at this period the physiography of the scarp was much simpler than it is now; we may

[1] The tufa deposits are dealt with more fully in the *Geol. Mag.*, September 1932.

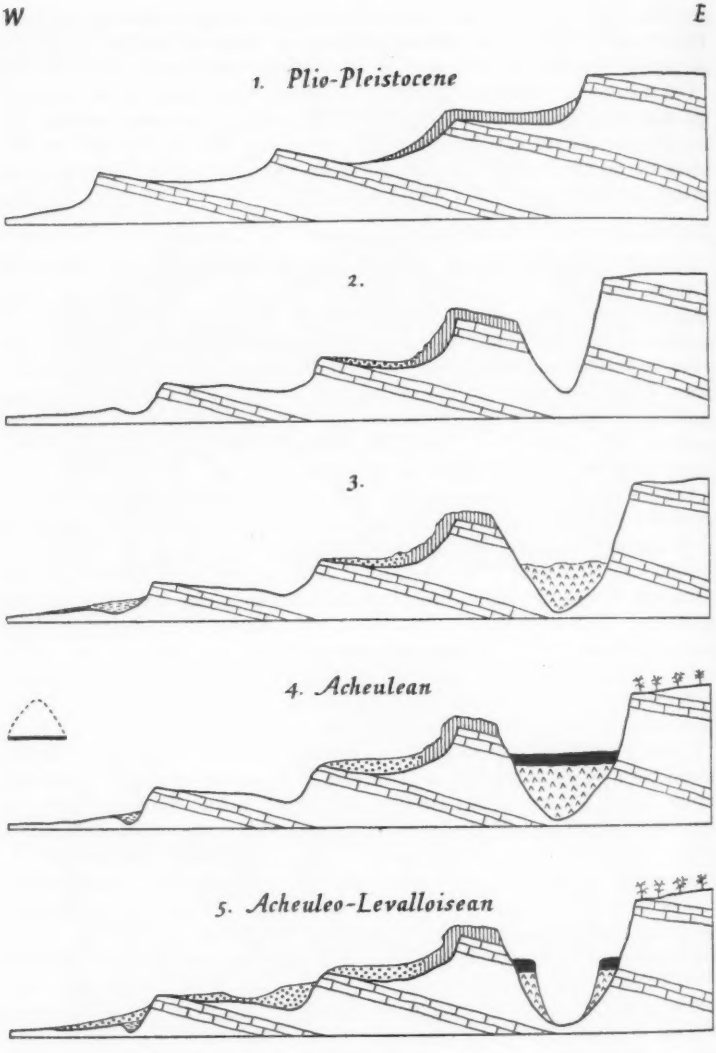


Fig. 3. Stages of physiographic development of the scarp

imagine the harder limestones and marls forming more or less continuous ridges below the main one, with broad gentle dip-slopes on their eastern sides. Across these dip-slopes the flood waters from torrential rains spread in shallow sheets, spilling over the scarp edges, evaporating, and depositing their dissolved lime as they went, thus building up by degrees a continuous bed of tufa. We could find no evidence for the date of this tufa; no implements, fauna or flora, except reed impressions were associated with it, and for the moment we can only tentatively term it Pliocene or Plio-Pleistocene on account of its relative position as the oldest of the "drift" deposits.

2. After this episode came a period of great erosion, probably representing increased rainfall (Stage 2). The Plateau Tufa was isolated from the main scarp by a longitudinal valley developed at the base of the dip-slope; while deep and broad transverse wadis cut through the lower plateaus as they drained down to the floor of the depression.

3. The next stage in the physiographic development (Stage 3) was the filling in of these early wadis, at least in their upper reaches, by great accumulations of breccia; angular masses of limestone and marl set in a fine angular matrix and showing no sign of water action. In places the breccia is 15 to 20 metres thick and stands out as great isolated pinnacles resting on the Cretaceous shales and marls. One such stack, over 20 metres in height, is seen in Plate 11, which shows also at its base, above the scree of the existing valley, the sloping floor of the primeval valley on which it rests. The amount of subsequent erosion gives some measure of the antiquity of this breccia; and the great thickness of the material collected under the influence of gravitational creep gives some idea of the length of time occupied in its accumulation. It must represent a prolonged dry episode in the history of the oasis; but we are unable to date it by archaeological means, and must content ourselves with its relative position in the scarp chronology. Noteworthy is the effect of this coarse deposit on the form of the modern wadis. These have everywhere had the greatest difficulty in scouring it away, with the result that the grade of the floors is much greater where they pass through the breccia, and the bed is filled with enormous boulders the size of cottages that make the wadis useless as means of communication (Plate 12).

4. With the passing of this arid period and the re-establishment of more favourable conditions, prehistoric man appears for the first time in the region.[1] Now there was enough rain to foster the growth of trees and ferns on the plateau and scarp. The run-off was highly charged with lime, probably owing to the humic acid provided by the vegetation; at the same time the sun was hot enough to produce rapid evaporation. These two factors led once more to the deposition of tufa on the breccia filling the old wadis, together with the accumulation of gravels and silts washed down by the intermittent but probably heavy rains (Stage 4). This tufa is sharply distinguished from the older series, the Plateau Tufa, not only by its position, but by its cellular structure, by the rusty-black as opposed to the blue-black weathered surface, and by the presence of leaves and branches of trees, and numerous land and freshwater shells. This type we term Wadi Tufa, irrespective of age. A cliff section exposed in the sides of a wadi, cut later through it, is seen in Plate 14. Special interest attaches

[1] We have not so far identified Chellean tools.

to the leaves and land-shells. The former are certainly not found in Egypt to-day, and if Zittel's determination of one type as *Quercus ilex* is correct, their home is to be sought in South Europe and Asia Minor. In addition to the ilex type, we have found at least six different kinds, whose identification would be of supreme interest. Unfortunately their preservation as casts is insufficient data for the palaeo-botanist to work upon. Plate 13 shows a fossil jungle of stems in a tufa exposure. It is certain however that a number of the land-shells are European; some are even living in England to-day, whilst others, with a remarkable incongruity which demands inquiry, now inhabit tropical Africa. Whatever this may signify, their presence in Kharga, now destitute of even the desert snail, emphasizes far-reaching changes. The age of this tufa is not in doubt, for we found sites of Acheulean date in the gravels and silts vertically below it.[1] Thus for the first time in Egypt a tufa has been closely dated. During this and the preceding wetter periods the stream waters had been gradually depositing on the lower dip-slopes great sheets of well-rounded gravels. These are the high-level Plateau Gravels, and at the Bulaq Pass they are one of the most striking physical features of the area. Their greatest development at the present time is between the 80 and 120-metre contours, and at these levels they must once have formed an almost continuous fan around the base of the Plateau Tufa outcrop (folding map 3) much as the gravels in the desert basins of western America fan out at the foot of the enclosing mountains. Now however these Plateau Gravels, as we have named them from their position, stand out as dark spurs and promontories isolated by the modern valleys (marked *d* on Plate 8), but still showing vestiges of their own drainage systems (Plate 15, and folding map 1, sections 3 and 4). The dark colour is due to the deep patina given to all the constituents by prolonged exposure. These gravels are culturally dated as contemporary with the earliest Wadi Tufa, for Acheulean tools were found in them, rolled and unrolled.

5. The succeeding episode (Stage 5) was again one of intense erosion, which partially re-excavated the old valley systems, cutting through tufa and breccia alike, and leaving them isolated on the watersheds between adjacent wadis, a position which is seen by reference to our Bulaq map. At lower levels intermittent streams meandered over the Plateau Gravels, still further rounding their constituents, and cut broad shallow valleys (Plate 15). The materials excavated were carried down to lower ground and spread out as great sheets of gravel and silt at the foot of the scarp, wrapping round the base of the older Plateau Gravels. These later gravels are distinguished by their lighter colour, due to the predominance of Eocene limestone not yet excessively patinated. We have called these the Exogyra Gravels, since they are best developed on the lowlying limestones and shales of this series (folding map 3). Archaeological evidence dates this and the succeeding episode to the Acheuleo-Levalloisean period, and this is of interest since it would seem to mark the maximum moist climatic peak of prehistoric times.

6. If the main erosional phases are to be attributed to increase in rainfall, the deposition of tufa and the partial filling of the excavated wadis with a gravel-silt-tufa series must be accounted for by a decrease in precipitation, the force of the waters being unable any longer to carry the load down to lower

[1] A photograph was published in *Man*, June 1932, Fig. 1.

levels. Such a period of aggradation followed the preceding erosion. Acheulean and Levalloisean tools are abundant in the gravels, and, as before, leaves and shells are found in the tufas and silts respectively. The series as a rule is deposited at lower levels than the earliest Wadi Tufa; the relation of the two can be seen at Abu Sighawal (folding map 1, section 1). In the Refuf Pass however the relation of the two series is rather different owing to the variation in local conditions. There the main sculpturing of the wadis took place before the deposition of any tufa, but the plateau type does not seem to be represented. From Acheulean to Acheuleo-Levallois times deposition was the order of the day: a 10-metre tufa underlain by a gravel with Acheulean implements is itself overlain by a thick series of coarse gravels with large tufa pebbles and containing numerous Acheuleo-Levallois implements (folding map 2, section 1). Here, as elsewhere, the gravel with tools passes up into white silts and ends with a 2-metre bed of cellular tufa. Since that time erosion has predominated at Refuf, and the modern drainage lines have been gradually developed.

7. The next stage at the Bulaq Pass was also one of erosion, indicating possibly a second maximum on the rainfall curve. The tufas and gravels of the Acheuleo-Levallois series were entrenched by wadis following practically the present drainage lines. In some cases the earlier deposits were almost entirely cleared out, leaving empty valleys ready once more to be partially filled in the next period.

8. A cycle or primary cutting, filling by breccia, deposition of tufa on that breccia, recutting, refilling, re-excavation, had now been accomplished. The sheets of Plateau Gravels had been laid down, and their constituents had been redeposited in the secondary plateau gravels of the Exogyra series. The Terrace Gravels, derived from both, and yielding at third hand much battered and travelled tools, were already in position at the foot of the scarp near the mouths of the old valleys. These vast changes are tied up closely by prehistoric evidence and were over by the close of the transitional period which joins the late Lower and Middle Palaeolithic. The main features of the scarp were now blocked out, ready to be finely sculptured detail by detail.

From this time onwards the rainfall, still considerable, seems to have decreased gradually but surely, though more tufas witness to the fact that at the beginning of this downward curve there was still enough moisture to support vegetation and land-shells similar to those of the earlier periods. The modern drainage system was becoming well defined: in some places the wadis followed the older ones; in others they cut across them. But wherever they are found they are of the same sort, namely steep-sided, almost vertical channels, in strong contrast to the wide, gentle, and smooth slopes of the old Plateau Gravel drainage. As formerly, gravels and silts capped by yet another Wadi Tufa were deposited in the valleys (Stage 8). These in turn are dated by their underlying implements to later Middle Palaeolithic times, and put at rest any doubts concerning the later date thus proposed for them.[1] It may be asked why we should assert that tools found in deposits—silts or gravels—underlying a tufa should date the overlying stratum: one might assume on the ordinary laws of stratigraphy that they were earlier. The answer lies in the mode of formation, itself diversified, of some at least of these tufa deposits: and as our

[1] A type section of this age was published in *Man*, June 1932, Fig. 2.

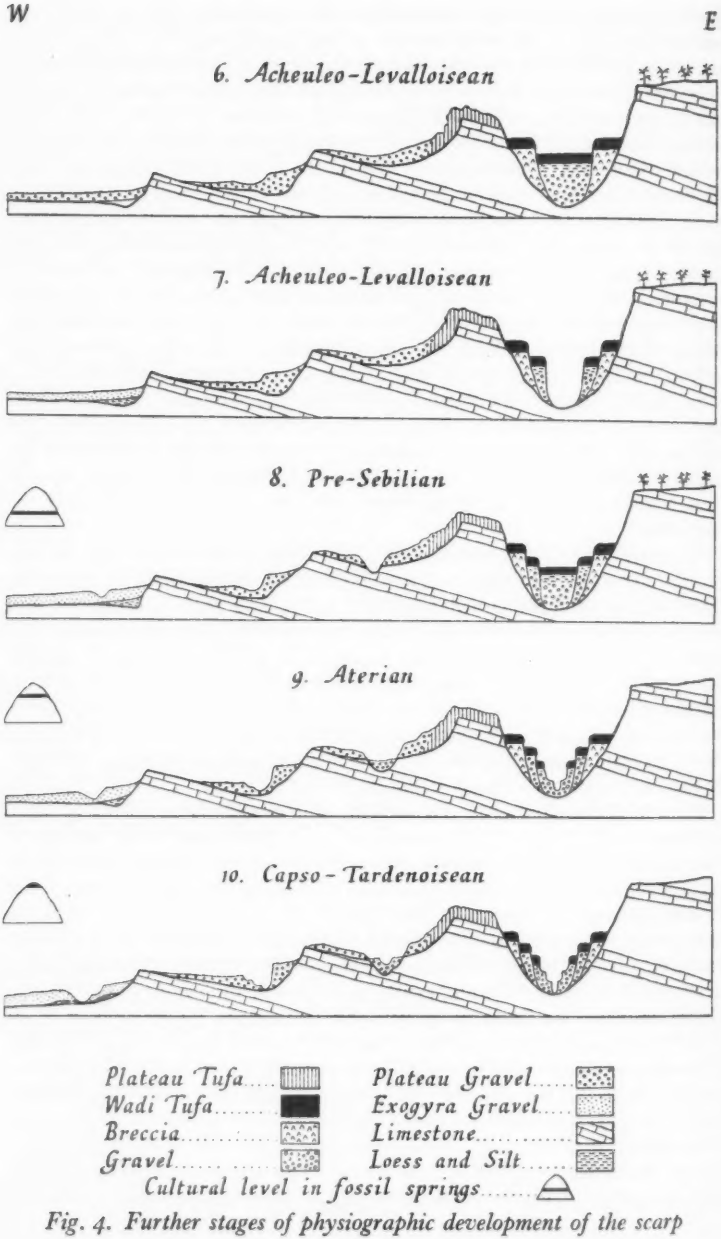


Fig. 4. Further stages of physiographic development of the scarp

interpretation is novel we will briefly outline the observations upon which it is based.

After the torrential scour of the valleys in the preceding period we find evidence for reduced deposition restricted now to the well-cut wadis. Valley gravels of the modern drainage system for the first time floor the wadis. Gradually blockages developed at narrow points, for the great scour of the preceding stages had undercut and loosened the primary, prehuman, breccia filling and its huge boulder-beds of limestone, and atmospheric weathering now began to cause great falls from the loosened banks of the new drainage system.[1] The gravel-bearing streams unable to shift these fallen masses further blocked their own courses, and ponding occurred above the dams thus formed. Velocity checked, finer gravels and then silts accumulated in the shallow ponding beds, and as evaporation acted upon the lime-charged waters a cellular tufa was built up.

Proof of this natural mechanism is frequent and in the field overwhelmingly convincing. Over and over again we have found traces of the boulder barrages with the tufas ponded up valley. Plate 16 shows a general view over an old ponded area of Middle Palaeolithic times. We stand beside the workmen and camel, on the Plateau Gravels, by that time already a watershed, looking down over the old mature valley with its shallow V. On these watershed gravels are incredibly huge flaking sites of late Middle Palaeolithic man, who chipped his tools overlooking the flood-sheet ponded up below in the old valley. The waters of that pond are witnessed by the surviving flat-topped ridges of its deposits—gravels, silts, and capping tufas—which appear in the hollow down below in the centre of the photograph. Farther down the valley narrows, and there in the far distance of the photograph, we found a huge boulder dam still more or less intact. Down on the water's edge, as well as on the surrounding hills, late Middle Palaeolithic man lived and made his flint implements of a variety we have provisionally named pre-Sebilian[2]; and in the gravelly silts underlying the tufa bed in that old flooded valley we found fifty-two of his tools. That is why we date that tufa by the underlying tools, for the deposits are interlinked phases of one ponding episode. It is of interest in considering the development of the three Wadi Tufas that the first (that of Acheulean age) follows a very dry period and leads up to a big erosional phase we take to indicate considerable rainfall; the second (that of Acheuleo-Levallois age) seems to occur on the downward curve from the maximum, though before this had reached the dry extreme of the breccia period there intervened renewed precipitation leading to a second erosional phase. Finally, at the dawn of the long downward curve culminating in modern desert conditions, a third and last Wadi Tufa (of pre-Sebilian age) was formed.

These facts are traced, as far as the rainfall and tufa are concerned, in Fig. 5, where the peaks of the curve represent the erosional periods. No attempt has been made to indicate the relative lengths of the different periods, though numbers 3 and 6 were probably longer than the others.

[1]Photographs in proof of these assertions were shown at the lecture. They have since been published in *Geol. Mag.*, September 1932, Plate XXIX, Figs. 1, 2.

[2]Evidently a localized development from the Levalloisean, but sufficiently distinctive in character and age to demand a specific name to distinguish it from its parent stock.

9 and 10. We now reach, with the dawn of the Upper Palaeolithic, the final stages in the physiographic history of the scarp, stages marked by steady degradation and the formation of terraces in the valley beds. From the Aterian culture phase onwards the struggle for existence for man, beast, and plant must have become ever more and more severe with each succeeding century. The trees and ferns gradually died out, leaving the scarp in barren desolation, and with them went all the land and freshwater shells. In the absence of vegetation and humic acid the rain could no longer dissolve large amounts of lime, and tufa formation ceased. Though the rainfall diminished progressively, it was still probably periodically violent, at least in the earlier Upper Palaeolithic stages, and in the course of time it accomplished a surprising amount of erosion. This can be seen in Plate 15, which shows a fragment of an old mature

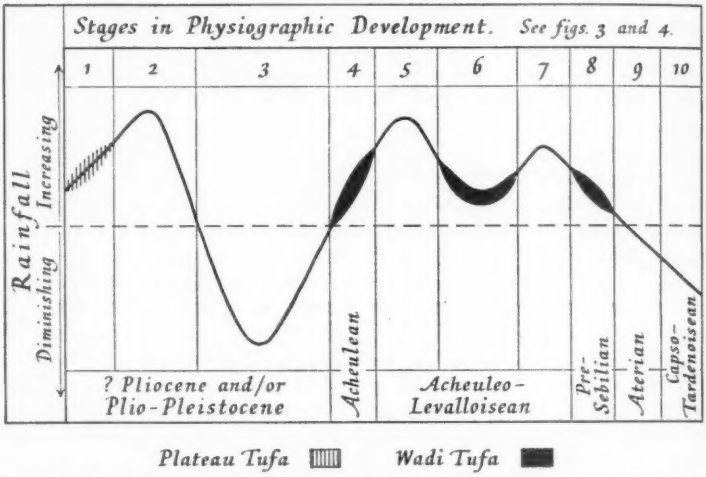
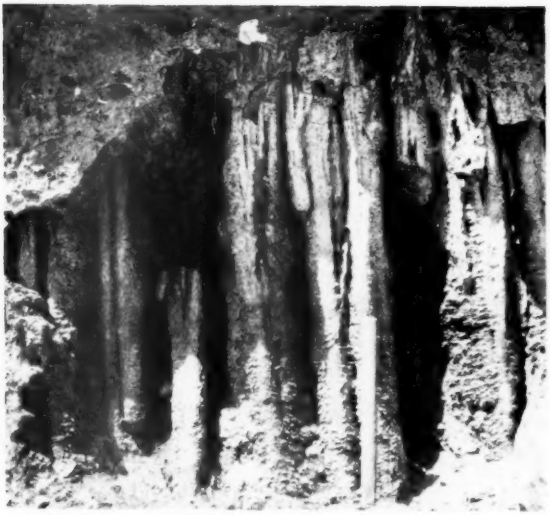


Fig. 5. Curve showing relative rainfall on Kharga scarp and suggested positions of plateau and wadi tufas

Plateau Gravel wadi (in the middle distance), now completely isolated by later drainage systems, some of which cut the old wadi course at right angles.

Another piece of striking evidence of the extent of later erosion was found at Site A in the 'Aqaba Wadi of the Bulaq Pass (seen in Plate 8). Here two terraces, marked *a* and *b* on the photograph, are well developed in the concave bend of the stream. The higher, 7 metres above wadi level, is dated by an Aterian flaking site in the silts overlying the gravels which form it (folding map 3, sections 1 and 2). On the south side this terrace is abruptly cut off by an almost sheer drop of 11 metres to the floor of a south-westerly draining wadi, marked *c* in the photograph. There is little doubt that this wadi, which is a tributary of a bigger one, has developed by headward erosion, until it has almost succeeded in capturing the 'Aqaba Wadi, now only some 30 metres away. The interest of this occurrence, itself considerable, is enhanced by the dating limit for it provided by the Aterian silts upon which this headward



13. Abu Sighawal pass: tree-trunks in tufa of Acheuleo-Levalloisean age

14. Bulaq pass: cliff of Wadi Tufa

15. Umm el Ghennihma: plateau gravel (foreground) and sloping gravels of mature drainage (middle distance)

16. Wadi 3, Bulaq pass: ponded area and barrage, Plateau Gravel watershed in foreground

erosion has encroached. Its methods of operation are discussed in the next section.

This 7-metre wadi terrace is the last and latest geographical feature in the scarp we can date culturally and closely. The lower, 5-metre terrace yielded no evidence for date, and thereafter no physiographical changes of importance, save erosional modifications still operative, took place.

Capsian man and his successors appear to have abandoned these slopes and valleys for the Libyan Plateau edge, where their sites are localized around shallow "pans" in which water collected, and still collects, after rain. Neolithic man, the last inhabitant of note in Kharga before the darkness of uninhabited desolation enveloped it for over four thousand years, resorted to the scarp edge to collect his flint, and the discovery of his flint mines, pitting miles of plateau edge with shallow workings, was one of our most interesting finds. Seen from the air the great extent of the flint-mine fields gives an impression of incredible activity extending, presumably, over a long period of time.[1] Nevertheless the cultural evidence would appear to be conclusive as to their Neolithic date alone. We found no evidence that Palaeolithic man mined his raw material—and it is questionable whether the tabular flint seams, so prized by his Neolithic descendants, were equally accessible in his day. The story of erosion outlined above would certainly suggest otherwise.

Headward Erosion of Desert Valleys

The method by which headward erosion is proceeding was demonstrated in a fine gorge near the Bulaq Pass. Its vertical walls, over 22 metres high, are composed of alternating shales and marls capped by gravel and tufa. The shales, being more easily eroded than the marls, are undercut, causing the marls to overhang and finally crash on to the wadi floor. Thus headward erosion proceeds, and at the present time the gorge, 1 kilometre long, ends upstream in an overhanging 11-metre cliff with a lip grooved and smoothed by water action. Above this fall the wadi is only some 10 or 11 metres deep, and still preserves the early stages in the development of the modern drainage system.

One peculiarity of this system remains to be noted. On looking at folding map 3 it will be seen that most of the wadis have very peculiarly curved courses. This is particularly true of Wadis 2, 3, and 6, which eventually join to form one great southern drainage line west of the lowest Exogyra scarps. Wadi 3 begins as a south-flowing longitudinal valley whose course is probably determined by an older longitudinal stream that was responsible for the high-level necks joining the two Plateau Tufa outcrops to the main scarp (see map). About 3 kilometres from the source the direction changes to east and west for nearly 2 kilometres, and then takes on a north-westerly direction till the plains are reached, when it once more swings around to the south. Wadi 6 starts with a more N.E.–S.W. than true N.–S. course, but the alteration from this to the E.–W. direction is much more abrupt than in Wadi 3, and takes place by means of an elbow bend. Wadi 2 does not penetrate nearly so far into the scarp, but it shows similar changes in direction. In this case however the flow at the source is from S.E.–N.W. for half a kilometre, then follows a more or less east-west section changing into a N.E.–S.W. one. It is obvious from the coalescence

[1] An air view and others were published in *Man*, May 1931.

of these three wadis that the development of the drainage system has progressed a considerable way.

In its simpler, earlier stages the theoretical directions of streams in a country of alternating hard and soft rocks with a gently easterly dip might be represented by a diagram (Fig. 6, Stage 1). The scarp slopes would give rise to wadis with short steep courses, the dip-slopes to ones with longer, gentler grades. The dip-streams of one slope would coalesce with the scarp streams of the ridge above, and in this case to the east, to form a longitudinal valley along the lowest part, namely at the foot of the scarp. In this way two or three independent drainage systems would develop; but they would soon cease to be independent, for erosion on the steep scarp slope would be much more rapid than on the dip-slopes, with a consequence that the scarp wadis would eat back by headward erosion till a dip-stream of the system above and to the east had been captured and finally the longitudinal wadi as well. This is represented in Fig. 6, Stage 2.

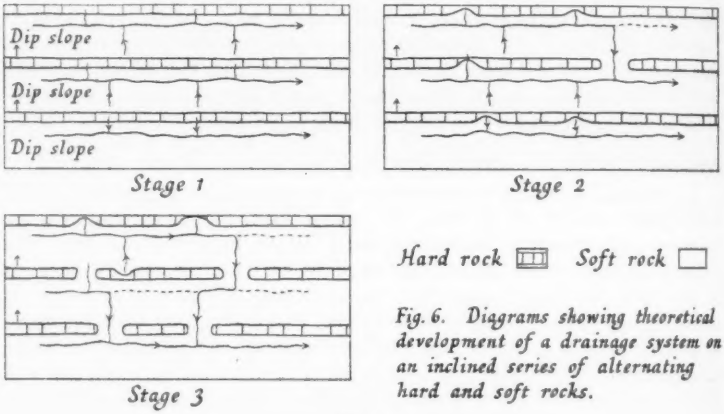


Fig. 6. Diagrams showing theoretical development of a drainage system on an inclined series of alternating hard and soft rocks.

Fig. 6.

The final stage may be represented by the capture of the middle system by the most westerly one, in which case there will be two reversals of flow instead of one (Stage 3). Some such explanation as this seems most reasonably to account for the courses of the wadis. The development is naturally not as perfect as that represented above, partly because of the influence of the older drainage system, partly because the original scarp edges had in places been much obscured by tufa, breccia, and gravel; but, as the W.–E. section of Bulaq shows, the tufas come down in steps, which probably correspond to the underlying structure, and therefore the modern drainage was still working on alternating dip and scarp slopes, though these were less well defined. There is no doubt however that once the superficial deposits were pierced, not only the dip and scarp slopes, but the alternation of hard and soft beds materially assisted the development of longitudinal valleys.

On this interpretation the N.–S. stretch of Wadi 3 at its source would represent the highest and most easterly longitudinal stream of the independent

systems; the N.W.–S.E. course the second; and the final southerly sweep the third longitudinal system. W.–E. directions are taken by the steep scarp streams which have worked back and captured the longitudinal ones. This hypothesis would also give a reasonable interpretation of the broad wadi, without present drainage, at the mouth of Wadi 4, and of the remarkable dwindling of the latter at its junction with the N.–S. line. The main drainage no longer comes down this line, but swings out beyond the Exogyra Gravels, leaving an empty longitudinal valley at the foot of the Exogyra scarp. In this case, then, there would be four, not three, longitudinal systems.

Mapping of other areas would probably prove if the development noted above can really be accounted for by capture, for in parts where there is less tufa and breccia the original topography may be better preserved and therefore a nearer approach to the ideal conditions obtained.

Climatic Evidences

(*a*) *Rainfall.*—Though the probable variation in rainfall has been noted in dealing with the physiographic development nothing was then said as to the absolute amount, and in view of the widespread belief that the North African desert was fertile in Pleistocene times it will be well to assess the Kharga evidence.

At first sight the occurrence of vegetation, land and freshwater shells, and tufa, together with a big development of well-rounded gravel and signs of extensive erosion, all suggest a very considerable precipitation in the Pleistocene. These facts, taken in conjunction with the possible movements of the climatic zones in the Glacial Age, naturally give substance to the idea that the Kharga climate might at that time have been Mediterranean in character, *i.e.* winter rainfall averaging about 20 inches per annum. In favour of this hypothesis is the presence of European land-shells and plants possibly of South European origin. The plants however are not definitely determined, and with the northern land-shells were others now living in the tropics. Therefore it would seem unsafe to argue a Mediterranean climate from this evidence. The most the fauna and flora definitely tell us is that there must have been more rain than at the present day; they give no indication of the amount.

Let us first consider whether the topographical features suggest a Mediterranean climate. In limestone regions of Mediterranean zones a characteristic type of country is that known as "Karst." This is a barren limestone surface deeply seamed with crevasses due to solution along the joints. Now the hard Eocene limestone that forms the top of the Kharga scarp is well jointed, and should be admirably adapted to show and preserve the Karst type of country had it ever existed. Near the edge of the plateau there are certainly big open joints such as those in Plate 2, but these are obviously due to the decay of the supporting rocks, and denote only the initial stage of the crumbling of the scarp edge. The Libyan Plateau, across which we walked the first season, is largely composed of this same limestone, and nowhere was any remnant of a Karst landscape preserved.

It might be argued that subsequent wind erosion had lowered the surface beyond the limits of solution, but since we have evidence to show that the period of increased precipitation lasted at least from Acheulean to late Middle

Palaeolithic times, it seems unlikely that wind would obliterate all traces of solution in what was probably the considerably shorter period from the Upper Palaeolithic to the present day. Further, the plateau shows all the signs of extensive wind action over long periods. The limestones are cut and grooved into fantastic shapes such as only wind can give, while there are innumerable shallow enclosed basins of varying size that could only have been formed by wind—some indeed seen from the air have a striking appearance of incipient Kharga depressions. On the other hand, a certain amount of water action and solution is shown by the presence, already mentioned (p. 371), of red earths in pockets and in cracks in the limestone. Professor Collet (*op. cit.*, p. 528) gives an analysis of one of these, a silt in a hollow at Kilo 92. He gives 46·18 parts in a hundred as soluble in hydrochloric acid, the greater part being calcium and strontium carbonate (41·19 per cent.), with 4·02 of magnesium carbonate and a trace (0·97) of sodium chloride. He states that the insoluble matter is mostly quartz of aeolian origin. Therefore even here there is no evidence of a very great amount of solution. Moreover it is significant that there are apparently no tufa deposits on the Libyan Plateau. If we are right in supposing that the presence of tufa in these regions is intimately bound up with the presence of humic acid, its absence from the plateau would seem to indicate that there was never sufficient vegetation on it to produce appreciable supplies of acid. Had the Kharga scarp conditions been at all widely spread tufa would surely occur on the plateau. Any reconstruction of the past climate must therefore explain its localization within relatively narrow horizontal and vertical limits, namely the eastern scarp slope between the 370 and 118-metre levels, which include both Plateau and Wadi tufas.

If the above argument is based on sound foundations it seems hard to escape the conclusion that the rainfall in and around the Kharga depression in Pleistocene times was not as great as that of Mediterranean regions to-day. Although the discovery of further evidence, or another interpretation of the facts, may invalidate this conclusion, yet it seems strengthened by comparison with other regions showing similar phenomena at the present time.

A close parallel seems provided in the more or less enclosed desert basins of Western America, such as Antelope Valley, California, etc., admirably described in various U.S. Geological Survey Water-Supply Papers.[1] High mountains there enclose more or less elongated troughs, into which gravels and alluvium are poured by intermittent, or in some cases perennial, streams. In comparing these areas with Kharga various important differences must be noted. The American basins are surrounded by mountains that stand 3000 to 7000 feet above the valley floors instead of a bare 1000 feet, as in Kharga. Further, these high lands are no great distance from a vast ocean from which blow prevailing moisture-bearing winds. The difference is shown in the great increase of precipitation in the mountains, where winter snows supply a large amount of water in the spring. Yet even so the lowlying ground between the mountains has an arid (10 inches) or semi-arid (14–16 inches) climate. Except that they are on a larger scale the gravel fans and cones built out by the streams as they emerge from the mountains on to the plain are very similar in nature to the Kharga gravels, which extend out some 18 kilometres from

[1] *E.g.* Nos. 277 and 288 (1911), No. 343 (1915), No. 423 (1917).

the scarp, but do not cover the whole floor of the depression. Moreover, in comparison with the American occurrences alluvial cones and fans are not so well marked, nor is the lowlying material at all comparable in thickness with that flooring the American valleys, where 500 feet and more are not uncommon. These differences again may be attributed to greater precipitation due to the height and position of the surrounding mountains; but if allowance is made for this, the conditions of the Kharga scarp in Pleistocene times must have been very similar to those obtaining now in these American valleys. Moreover, the American regions show how great may be the precipitation variant between floor and bounding scarp, and consequently in the Kharga region, even when a conclusion has been reached as to the rainfall on the scarp, it does not necessarily apply to the floor of the depression 350 metres below. In these American valleys, save for deposits from hot springs, tufa is absent, mainly because the surrounding mountains are not calcareous.

We must therefore seek some other region for a parallel; this can be found in the tufa now aggrading the stream valleys of the Bahia Plateau, Brazil. Here, just south of the Rio São Francisco, a limestone area is drained by north-flowing tributaries. The occurrence and mode of formation of the tufa is described by J. C. Branner,[1] and his account might be taken almost word for word to describe the Kharga tufas. What concerns us here however are the climatic conditions under which this modern deposit is being laid down. He states that the rainfall is confined to a few months in the year and is never great. At Joanzeiro, on the northern borders of the region, the *Géographie Universelle*[2] gives the precipitation as 246 millimetres (9·7 inches) per annum; but the rainfall varies rapidly in this region and not many records are available. Branner's statement however makes it clear that tufa of this type can form, and perhaps must form, under semi-arid conditions. Further, he states that it is laid down in "those portions of the valley in which the streams are not perennial." The tufa is covered by a short scrubby forest characteristic of most of the semi-arid interior, and from its name, "Catinga," Branner calls the calcareous deposits "Catinga limestone," a name that might well be adopted for the Kharga tufas, for the abundant leaves and branches show that it too was covered with vegetation, probably of the same scrubby character, though naturally not of the same species.

If the above parallel with Brazil is accepted as applicable to Kharga, then the preceding arguments in favour of an arid or semi-arid climate at the time of the formation of the tufa receives very strong support. Arid is here used to denote a rainfall of 10 inches per annum or under. At the present time it is practically nil, but the springing up of vegetation on the wadi floors, even after the very occasional rainstorms of to-day, is an indication of the enormous changes that might be produced by a rise in precipitation to even 10 inches, especially if it were concentrated in one portion of the year. The comparison with Kharga is made all the closer by the fact that the Brazilian streams, in which only aggradation is now taking place, were once capable of eroding their channels. This Branner attributes to increase in the rainfall consequent on elevation.

[1] *Bull. Geol. Soc. America*, 22, pp. 187–206 (1911).
[2] T. XV, Pt. I, 1927, p. 156.

The conclusion from the above argument as to the Kharga rainfall during the Pleistocene is that for the periods of tufa formation it was small, possibly 10 inches, certainly not over the semi-arid 16 inches; but that in the big erosional phases corresponding to true "pluviations" in other regions there was an increase of unknown amount, but not equal to that of Mediterranean regions or of the mountains bordering some of the American desert basins (in one instance given as 27 inches per annum) and possibly not exceeding the semi-arid 14 to 16 inches.

To sum up: the evidence as we see it for the climatic conditions on the floor, as opposed to the scarp, of the Kharga depression in Pleistocene times seems to denote predominant aridity, broken only by the small oases formed by the natural springs, and by the occasional incursions of gravel washes from the scarp. If this is true the greater rainfall of the scarp must be attributed to its greater height, which allowed the condensation of moisture brought by winds more fully saturated than they are at present—winds probably to be correlated with the disturbances in the atmospheric circulation produced by the advance of the great ice-sheet over northern Europe, and here on the extreme limit of their effective operation. Kharga, as we view the new evidence, is not a region in which the term "pluvial periods" can be used in any but a strictly relative sense, denoting temporary and not very pronounced departures from a norm of aridity, albeit departures sufficient to convert full desert to poor steppe.

Synthesis of climatic evidence between the Faiyum and Kharga Oases must await a third season's work, directed mainly to sources of water; but it is already apparent that the two depressions are yielding unequal though not contradictory evidence: an inequality due, it would seem, to the relative intensification of climatic variations in the former area occasioned by a difference of 4° of latitude between them. The distance of 400 odd kilometres separating the two oases is evidently more critical than might have been supposed, and supports Antev's contention that the influence of the southerly migration of the Mediterranean belt in Pleistocene pluvial times was not felt south of latitude 25° N., which, as it happens, runs through the centre of Kharga.

(*b*) *Scarp Drainage Run-off.*—The question of the ultimate fate of the scarp waters, raised on page 381, was postponed till the evidence enabling reasoned judgment had been put forward. If they did not form playas or dry lakes on the floor of the depression, what became of them? We suggest that since no evidence was found in support of playas formations, the scarp run-off was disposed of partly by absorption and partly by evaporation. The absence of tufa in the lowlying areas would be accounted for by its deposition at higher levels in times of diminished rainfall, and by the greater rapidity of the run-off during the bigger erosional epochs.

Some check on this conclusion is provided by a comparison with modern arid regions in America. H. R. Johnson, in his account of the Antelope Valley, notes that the sudden diminution in flow of the streams as they enter the valley is characteristic of the arid west. He states that "except during periods of heavy precipitation, the streams without exception sink beneath the gravels of the valley at a distance of not more than 3 miles from the mouths of their canyons."[1] We have noted above that the run-off from these American

[1]Water-Supply Paper No. 278 (1911), p. 12.

mountains is, in all probability, many times greater than that from the Kharga scarp, even in its pluvial periods of maximum precipitation. Moreover, Kharga is 10° of latitude south of the Antelope Valley, and the temperature, and therefore the evaporation, would have been correspondingly greater.

Summary

We may now summarize the prehistoric geography of Kharga in relation to Palaeolithic and Neolithic man up to the point to which, in two seasons' work, we have unravelled it. This seems most conveniently done in tabular form. Since however geographical studies recognize no historic limits, and the prehistorian likewise has to include in his field-work all history, the later story of the oasis, as we have traced it there, is extended summarily to modern times.

Period	*Associated Events in the Depression*
Arab (A.D. 640–).	Progressive deterioration till Nile branch railway built in 1908. Dr. Ball published Geological Survey Report, 1899. Geological report by Captain (Sir Henry) Lyons, 1893–4. Rohlf's scientific expedition visited oasis 1873–4, when Zittel inaugurated geological investigations.
Byzantine (A.D. 395–638).	Christian settlements. Nestorius banished to oasis 434. Buildings extended and irrigation maintained.
Roman (30 B.C.–A.D. 395).	Temple and fortress building. Artesian water fully exploited. Mining on large scale. Extensive cultivation. Desert trade routes organized.
Ptolemaic (332–30 B.C.).	Temple and fortress building. Development of irrigation and cultivation.
Persian (XXVIIth dyn.) (525–332 B.C.).	Artesian water supply opened up by deep wells; subterranean aqueducts cut and oasis rendered habitable for civilized occupation. Temple built by Darius the Great. Cambyses' lost army believed to have passed through Kharga on march to Siwa.
Predynastic to Persian (*circa* 5000–525 B.C.).	No Egyptian remains. Oasis practically uninhabitable for lack of water: the haunt of Libyan badawin watering around small seepage pools from Surface Water Sandstone. Their traces identified in a small settlement of Pan-grave type, possibly dating 1700–1600 B.C.
	Associated Physiography
Neolithic (ends 5000 B.C.).[1]	*Floor*. Dune-sand covers dying to dead springs. Desert conditions (p. 387). *Scarp*. Flint-mining settlements (p. 397).

[1]Dates for this and the earlier periods are pure guesses and as such are valueless except in so far as they may indicate to the non-archaeological the sorts of dates which prehistorians now envisage as possible.

	Associated Physiography
Late Upper and Mesolithic	
Capso-Tardenoisean (ends 7000 B.C.).	*Floor*. Dying springs. Drift-sand accumulates; oncoming of dunes (p. 387). *Scarp*. Clay pans hold periodic storm rain (p. 397). 5-metre wadi terrace cutting? (p. 397).
Capsian (ends 10,000 B.C.).	
Early Upper Palaeolithic	
Aterian (ends 14,000 B.C.).	*Floor*. Springs in penultimate stage of mound-building, preceding accumulation of earliest drift-sand (p. 384). Trend towards oncoming desert conditions. *Scarp*. Deposition of silt on 7-metre wadi terrace and in solution pans in tufas (p. 396). Decreasing rainfall.
Middle Palaeolithic	
Pre-Sebilian (ends 20,000 B.C.).	*Floor*. Older springs in full activity of mound-building; newer ones still irrupting (p. 385). Gravels carried 18 kilometres out over depression floor. *Scarp*. Ponding of some wadis and final wadi tufa deposition (p. 395). Formation of final drainage system. Cutting of 7-metre wadi terrace (p. 396). Moist conditions decreasing towards end of period.
Levalloisean.	
Transitional Lower to early Middle Palaeolithic	
Acheuleo - Levalloisean (ends 30,000 B.C.).	*Floor*. Not identified, but presumed continuation of spring activities. *Scarp*. Maximum of moist conditions. Long period of immense physiographic changes. Formation of mature drainage in Plateau Gravels, and deposition of secondary sheets of Exogyra Gravels at lower levels. Excavation of wadis and formation of Wadi Tufa (pp. 391–3).
Late Lower Palaeolithic	
Acheulean (ends 60,000 B.C.).	*Floor*. Earliest spring outbursts (p. 387). *Scarp*. Deposition of Plateau Gravels. Formation of Wadi Tufa (p. 391). Establishment of Pleistocene moist cycle.
Pre-Chellean to early Acheulean	
Locally Prehuman.[1]	*Floor*. ? Loess-like accumulations in hollows (p. 380). *Scarp*. Formation of breccia in primary wadis (p. 391). Long arid period.
,, ,,	*Floor*. No evidence. *Scarp*. Cutting of primary wadi system. Gravel deposition (p. 391).
,, ,,	*Floor*. No evidence. *Scarp*. Formation of Plateau Tufa on Tertiary (pp. 389–391).

The great hiatus here shown separating the history of man in Kharga into two cycles, a prehistoric and a relatively modern, is one of the most unexpected facts which the investigation has yielded. On the one hand archaeology fails

[1]Need not necessarily directly precede the Acheulean.

to discover any evidence for habitation of the depression by people of Egyptian culture in dynastic times—a failure probably not due, we think, to the accidents of field-work in a large area only half of which is yet explored. For the topographical peculiarities of Kharga decree that all traffic to and from the Nile Valley shall be canalized into narrow passes in the boundary cliffs. These passes then are foci of human movements past and present; and whereas we can prove them to have been much used by prehistoric man whose flint implements lie about them in remarkable quantities, there is after his departure a hiatus of several thousand years, until activities, as announced by those indestructible chronometers, broken potsherds, recommence in classical times, and continue progressively till late Roman times, when the breakages assumed alarming proportions. Archaeology notes these facts as perplexing and possibly significant, and puts them on one side in a suspense account.

But when, on the other hand, physiographic study shows the dependence of prehistoric man on springs long fossilized and hitherto unknown, and can further show their failure in local Neolithic times; and when, additionally, the only alternative water supply, without which the oasis would be barely habitable, is accessible only by deep borings through scores of metres of rock, we believe we are justified in transferring that suspense account to the credit balance by suggesting that Kharga was, in fact, practically uninhabited in dynastic times until the Persian conquerors of the XXVIIth dynasty transformed the depression by the boring of deep wells to tap the artesian water, and thereby inaugurated the second and classical cycle of Kharga's prosperity.

The direct dating of the artesian wells is probably an impossible task, and when we suggest a Persian origin we do so on bilateral evidence. In the first place it seems to us improbable that riverain Egyptians, children of the inexhaustible Nile, conceived the idea of water-boring at great depth in a sterile and distant depression; or that, the idea existing, they would have done so in view of the danger of presenting maurauding Libyans with a *point d'appui*. In the second place, the Persians, the earliest civilized conquerors of dynastic Egypt, are renowned for their hydraulic engineering and their ingenuity of contrivance in exploiting and storing water; and when, combined with this known aptitude, we find their exotic civilization established in Kharga as herald of its sudden outburst of classical importance, we regard the trend of evidence as strong, and worthy to be borne in mind when weighing against it older established and apparently conflicting evidence.

This is the pre-Persian stela referred to on p. 373, found in Dakhla Oasis,[1] which dates to the reign of Sheshonk I of the XXIInd dynasty, a dynasty of Egyptianized Libyan usurpers of the pharaonic throne. This stela, which "both in form and language plainly betrays its half barbarous origin at the hands of partly Egyptianized Libyans,"[2] records a dispute about the ownership of a well, and alludes amongst other things to the "chief of irrigation" and to an inspection of "the wells and cisterns which are behind the oasis."[3] It is therefore impossible to rule out the fact that wells already existed in Dakhla Oasis, if not in Kharga, a considerable time before the Persians. But the

[1] Spiegelberg, *Rec de Trav.* xxi, 12.
[2] Breasted, *Records*, iv, 725.
[3] *Idem*, iv, 726.

question possibly remains open whether these were necessarily artesian borings to depth, or were not more modest artificial exploitations of natural springs, a work more in scale, it seems to us, with a semi-barbarian Libyan population than highly skilled artesian drilling.

In the opinion of Mr. Beadnell[1] "there seem to be [in Dakhla Oasis] no natural passages extant at the present day, from the sandstone through the Red Clay to the surface. The water, in fact, appears to flow to the surface entirely through artificial passages, that is to say, bore-holes. How, and in what quantity, water found its way to the surface before the first artificial wells were sunk is not known. Probably springs were few and far between, judging by the thickness, impermeability, and extent of the Red Clay as proved by recently made borings."

The answer to these questions may be given by further field-work.

DISCUSSION

Before the paper the PRESIDENT (Admiral Sir WILLIAM GOODENOUGH) said: Before we proceed with the business of the evening may I call the attention of Fellows to the very charming carpet on which we are standing? It is a present from one of our Fellows, Miss Tucker, and I am sure I am voicing what we all feel when I express to her on your behalf our great gratitude.

We have had more than one lecture or paper in the *Journal* on the Libyan Deserts, giving descriptions both of the deserts and the oases in their present condition, by Dr. Ball, Major Bagnold, and others. To-night we are to hear something of the most ancient times in connection with those places: how long ago it was a settled country, what its civilizations were likely to have been, and, in particular, what natural evolution and phenomena caused the widespread movements of the human race which we learn have taken place. We are to hear of it from one who is well qualified to speak. Miss Caton-Thompson, our lecturer this evening, became a student in archaeology in Egypt; she has excavated in many parts of that country, and most of you will remember that in 1928 she was appointed by the British Association to conduct excavations at Zimbabwe and other Rhodesian sites, where she has put in an immense amount of work. To-night she will speak to us of the ancient history—the prehistorical geography, she prefers to call it—of the Libyan Desert.

Miss Caton-Thompson then read the paper printed above, and a discussion followed.

Dr. SANDFORD: It is a very pleasant task to congratulate Misses Caton-Thompson and Gardner on their excellent research in Kharga Oasis. About two and a half years ago this Society listened to them in another place, not as splendid as this, when they told us of their researches into the waters of the historic Lake Moeris, in the Faiyum. They had found it necessary as a result of their investigations to dispose of certain archaeological theories concerning that lake, and from the remains of those theories, and more especially from their own researches, there arose a new and better Lake Moeris, which was not only historic but prehistoric also. Now, after a period during which Miss Caton-Thompson has been doing pioneer work at Zimbabwe, they have returned together to Egypt, to Kharga, a neighbouring oasis—though 200 to 300 miles away from the Faiyum. The first thing they do is to dispose of lakes altogether, which at first, after all their work on lakes, comes as rather a shock. Then we see

[1] Geological Survey Report, 1899, "Dakhla Oasis," p. 19.

the reason for their boldness when we follow their work a little further and see some of the results of their labours.

It is difficult to follow immediately the whole of a long paper, especially when filled with so many results as is this one; but I must confess that I am a little bit doubtful still about that prehuman desert period when the loess-like layers were deposited. I shall look forward to reading the paper and to getting a little more information in due course. But apart from that very early period it seems to me that the whole of the history of Kharga is one of water, sometimes a great deal of water, depositing gravels, huge boulder-beds, and so on, all through history until a comparatively late stage of Palaeolithic man. That relieves us of a little difficulty in following the results of Miss Caton-Thompson and Miss Gardner's work in the Faiyum, because, if I understood their work, I gathered that they thought there was a Mousterian period of aridity. But a little farther south it seems now that the history was perhaps one of a damper climate. That is exceedingly welcome as far as I am concerned in the work I am doing in the Nile Valley, because there I think we have almost an unbroken record of rainfall from Pliocene times onwards, and we have found out that in the valley the rainfall slackened in a remarkable way in the later part of Palaeolithic times. When we have had the opportunity to trace that change a little more closely, I think the history of Kharga will prove to be in close continuity with the history of the Nile Valley. I shall look forward to the appearance of the paper, and I would like to offer my very sincere congratulations to Miss Caton-Thompson and Miss Gardner on the remarkable piece of work that they have done.

Professor J. L. MYRES: It is a very great pleasure to join in thanking Miss Caton-Thompson and Miss Gardner for the great addition to our knowledge which has come from their work in the Kharga Oasis. As Miss Caton-Thompson said to begin with, it has been a piece of work where it has been possible for a skilled geologist and palaeontologist on the one hand, and a skilled archaeologist on the other, to apply new criteria to the solution of a geographical problem. These curious land-forms within the Kharga depression have been a puzzle, and other explanations of them held the ground for quite a while; it was by tackling the problem quite from the beginning upwards, by fresh methods—and by a remarkable combination of skill, persistence, and endurance—that these revolutionary and suggestive conclusions have been won. When you consider the practical difficulties and the necessity for ingenious extemporization of methods and means required I think you will agree it has been a very fine piece of work.

Mr. BALFOUR: Mr. President, ladies and gentlemen, I have very little to say, because I must confess that most of what I know about the archaeology of the Kharga Oasis has been learned from Miss Caton-Thompson, so that I am not in a position to debate anything which she has laid down. But I would rejoice with her on one point, and that is that the Royal Geographical Society is recognizing that archaeology is one of the kindred subjects in which geographers can take real interest. I feel that this is very important indeed, because we are concerned as archaeologists with problems which deeply concern the geographer, and the research which is being done to-day, which is so well exemplified by Miss Caton-Thompson's careful work, aims at the solution of very wide problems, with which geography must necessarily be concerned: problems connected with the whole early history of the human race.

We do not yet know where human culture originated. There have been many speculations as to where the so-called "cradle of humanity" and of human culture was originally located. In the old days it was assigned to the Central Asiatic plateau. There was a very good reason for that: the Central Asiatic plateau had not been exploited archaeologically, and therefore it formed a very

convenient dumping-ground for the unknown, and was thus credited with having been the nursery of this cradle of human culture. Then in later times this cradle started rocking. When the Piltdown man was discovered in Sussex there was an oscillation towards the West. There was another discovery in Africa, and another oscillation, southwards this time; and then the cradle lurched heavily towards China, owing to the discovery of the remains of *Sinanthropus pekinensis*, whom Professor Elliott Smith, rather unkindly I think, refers to as "The Man of Sin." And there had been another earlier south-easterly oscillation, caused by the discovery of Pithecanthropus in Java. Well, it is still rocking; but there is a tendency, owing to the researches of Leakey and Wayland in East Africa, and to researches in South Africa, to concentrate more and more attention on the African Continent as a focussing point of interest in prehistoric archaeology; and it does seem likely that, even though the "cradle" may not be found there, we may find a good many pieces of evidence which will gradually fill up some of the very early chapters in the evolution of man's history, and may even assist in bringing the restless, rocking cradle into a state of equilibrium and localized stability.

It is with the hope that these early chapters may be gradually filled up and elucidated that one welcomes such intensive and highly scientific work as has been done by Miss Caton-Thompson and her capable and energetic colleague, Miss Gardner. I would like personally to thank Miss Caton-Thompson for the work she has done, and I speak as an archaeologist rather than a geographer. I thank her heartily for having thrown considerable light on some of those rather mysterious early chapters in the palaeolithic portion of our history which, when correlated with other evidence from elsewhere, will gradually fill in a volume which will be both interesting and instructive.

The PRESIDENT: First may I say how grateful I, on behalf of the Royal Geographical Society, am to Dr. Balfour for what he has said about the recognition of kindred interests here. It is quite true that we do our utmost to realize how closely allied we are with all those kindred subjects. I know I have said at various times that we do believe that geography is a science—my predecessor would not have it that it was a science—without which mankind cannot progress.

There was one point—I am not an expert on these matters—which struck me as being of great interest, looking back to Miss Caton-Thompson's work in connection with that of others, that is the very interesting chart made by Dr. Ball of the water-levels of the Libyan Desert. It makes a most interesting study. It seems to me that the same sort of problem as is put forward here exists in other parts of the world, the Taklamahan and the Rub' al Khali. Do not let anybody think these investigations are matters of pure science, as it is called, or curiosity. An ordinary person, like myself, may think these matters are probed into simply from curiosity. It is not so. Such things as we have heard to-night form examples of what may happen in the future, and it is quite possible that through the work of Miss Caton-Thompson and Miss Gardner we may discover why it is that we have places, once fertile, becoming desolate, and places once desolate becoming fertile, and from these investigations may find out what places on the earth are useful for human occupation.

I always used to think, in reference to what Dr. Balfour said about where man came from, that man came from Asia because the Garden of Eden was there. As to prehistorians and prehistory, there we are: it does seem to me that the excavations of Miss Caton-Thompson and Miss Gardner have added to our knowledge of history. Miss Caton-Thompson has given to some of us a new subject of the greatest possible interest. We have seen the immense amount of work she and her companion have put into it, and the extraordinary interest she

evidently takes in it and gets out of it; and the way she has told us about it has added to our interest and pleasure as well. I would therefore ask you to accept on behalf of our Society, Miss Caton-Thompson, our sincere thanks for your most admirable piece of work, and also for the interesting diagrams you have shown on the screen.

Professor H. J. FLEURE, *who was unable to be present at the meeting, has sent the following contribution to the discussion:* It is a special pleasure to have an opportunity of contributing an appreciation of the work of Miss Caton-Thompson and Miss Gardner. It is a clear gain to have the problems of the formation of the depression at Kharga dissociated from those of its occupation by man; it is also a relief to have Dr. Ball's views confirmed, so that we need not further discuss problems of former courses of the Nile. These are welcome simplifications.

The problems of climatic changes in Pleistocene times in Europe and Africa have been engaging attention thanks to the efforts of Wayland, Leakey, and Armstrong. A certain possible parallelism between equatorial Africa and Europe has been suggested by some of these workers, and it has therefore become necessary to know what happened in the intermediate region. The present paper supplies invaluable evidence of spring activity apparently due to a higher water-table, and allows for some supplementary moisture from a very moderate rainfall on the scarp. It is interesting that from the period of the Acheulean tools onwards to that of the Capso–Tardenoisean no marked period of aridity intervenes, but such a period of aridity did occur before the men of the Acheulean culture arrived, and that was preceded, in its turn, by a moister period. It seems possible to use as a working hypothesis the idea that the arid time may have been mid-Pleistocene and that the men of the Acheulean culture may have come to Kharga relatively late. The absence of dynastic peoples is an important point to have established and the undertaking of engineering exploits under Persian guidance has analogies elsewhere.

EAST OF THE ECUADORIAN ANDES

H. L. HOLLOWAY

EARLY in 1931 I was commissioned by an English Company to write a report on the geology and the occurrence of economic minerals in the almost unexplored tract of territory lying to the east of the Ecuadorian Andes, known as the Oriente Province. I landed at Guayaquil in the first days of March of the year mentioned, and from there proceeded comfortably to Quito, the mountain capital, by railway. Two days were taken up by the journey, the train halting for the first night at Riobamba, a little more than halfway. There are two routes by which to enter the northern portion of the Oriente Province: one by way of Quito—Papallacta—Baeza—Archidona; the other, and easier one, by way of Ambato—Baños—Mera. It was by the first of these routes that Hamilton Rice entered in 1903, and I decided also to take that way. The first 16 miles from Quito to a small town called Pifo can now be covered by motor, and the mule track has been extended from Papallacta to Baeza since Hamilton Rice made his journey; otherwise there is little change in the conditions of travel from those described by him. The first day's mule ride brought us to Papallacta, credited as being the original home of the potato and as having given that comestible its name *papa* in Spanish. The bleak *paramos* across which we rode were bitterly cold, and it was hard to believe that we were only a few miles south of the Equator. The country near Quito is of a volcanic nature, tuffs and lava flows, which later give way to the schist formations which form the backbone of the Eastern Cordilleras. Before Papallacta is reached, the open country is left behind, and thereafter the bush becomes ever deeper as the path descends to lower levels. Long before Baeza is reached at the end of the second day's ride one is in the unbroken forest. Baeza was founded in 1558 by the Conquistadores and became a town of some importance, but as the settlements started towards the east declined, it fell into decay. It is now only a collection of a few poor houses. At that point we left our mules and continued the journey on foot, our baggage being borne by Indians, who by arrangement with the Government officials had come from Archidona to meet us.

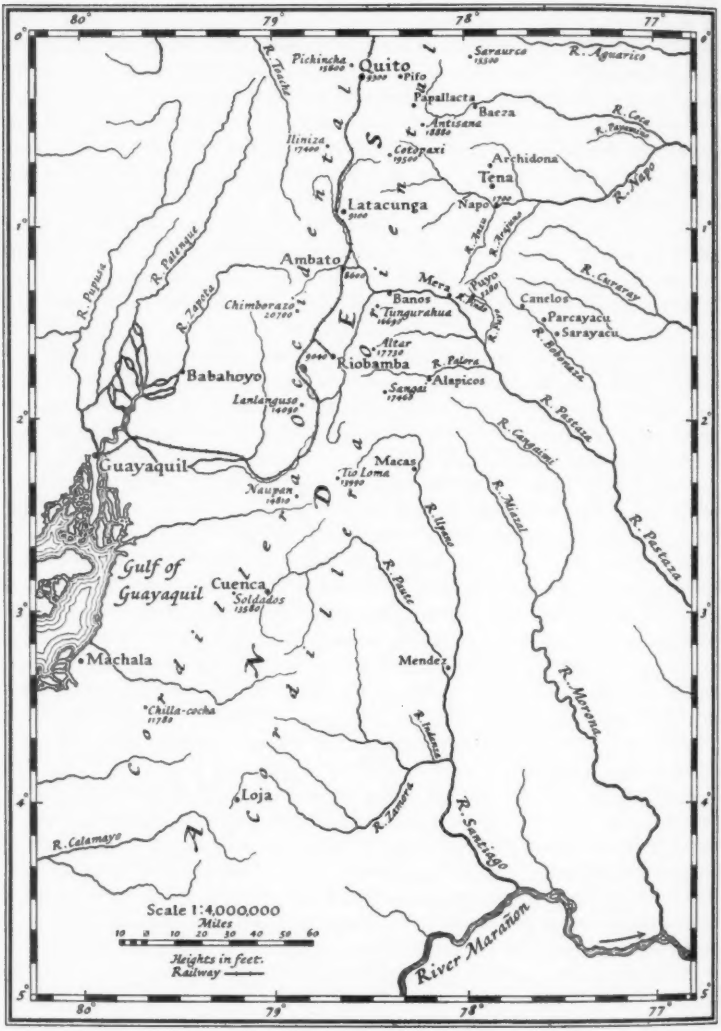
The dominant feature of the track from Baeza to Archidona is mud. It took us four days to cover this portion of the journey, the nights being passed in *tambos* or rest huts, built at intervals on the route by the Government. Archidona was founded in 1560, and was for a long period an important town and the administrative centre for the Quijos Province, but after the Indian rebellion in the Macas territory to the south in 1599 all the Spanish settlements in what is now the Oriente Province dwindled to a shadow of what they had been. The political centre is now Tena, some 10 miles to the south, founded at the same time as Archidona, but the latter settlement is still one of the chief seats of the Roman Catholic Mission in the province. It represents the gateway into the lowlands, and on a clear day immediately to the west there looms up the huge bulk of the Andes, while to the east lie the vast broken plains of the Amazonian headwaters. From Archidona a good horse road leads to the village of Napo on the river of that name, *via* Tena, a distance of some 15 miles. There is a certain amount of settlement along the road and a number of

pioneer haciendas are passed, homes of white settlers from the mountain plateau. Coffee is grown and, as everywhere else in the province, is of an excellent quality. Tena consists of some fifteen houses, well built for that part of the world, with Government offices, Catholic Missions buildings, and church, and with an American Protestant Mission in the close vicinity. Napo village is much smaller and consists only of four or five houses built around a small clearing on the left bank of the river. Before it the Napo river, here some 250 yards wide, flows swiftly between banks of interstratified bituminous shales and fossilized limestone. In many places semi-liquid bitumen oozes from clefts in the rocks, and one day this district may become an important oil-bearing zone.

The Indians of the upper Napo, called collectively Napos, do not live in the settlements with the white, or rather light-coloured people, or even in tribal villages, but distribute themselves in solitary houses in the surrounding forest. They are a peaceful race with few vices other than a strong disinclination to sustained work and an equally strong inclination to day-long toping of the *chicha* made by their women. They are in general of good physique and sufficient intelligence, but without ambition of any kind. They are neither a morose nor a silent people, as they have sometimes been described, but are quite ready to converse freely with any one who can understand the Quichua language which they speak, and burst into noisy laughter on the slightest provocation. Most of them owe some kind of allegiance to some one of the white settlers, whom they call their Patron, and to whom they are bound by debt contracted for cloth or other articles for their use; for this Patron they do sporadic work. Their dress has little distinction, being a mixture of European and native. Their chief food consists of the chicha already mentioned, with such game and fish as they may be able to come by. They cultivate plantains (*Musa paradisiaca*) and cassava (*Manihot utilissima*), the latter chiefly for the making of chicha. To make the chicha, the food to be used, usually cassava, but in season also the fruit of the Chontadura palm (*Bactris* sp.), is cooked, then pounded into a mass. It is then chewed by the women, a mouthful at a time, until the whole is impregnated with saliva, after which it is put away to ferment. In a few days it assumes the consistency of a batter and is then called *masuta*. For use, a handful is mixed with water, the stringy fibres picked out, and it is then drunk as a thin gruel. It has a slightly intoxicating effect, but appears to incite rather to good humour than to belligerency. For long journeys the Indians take no other kind of food than bundles of *masuta* wrapped in leaves. These bundles they bury in the mud of the stream beds on the outward journey, fishing them out on the return. The preparation of *masuta* is one of the few customs general with all the Indian tribes of Eastern Ecuador.

My first journey on the Napo river was upstream to a point known as Amaron Carchi. Above the village of Napo the river is navigated with ever-increasing difficulty because of the rapids, until progress by water is finally barred at Talum Pungo, only about 7 miles upstream, but a full day's hard poling. There is an Indian trail which leads from Talum Pungo west along the Napo valley, then through the Andean passes to Latacunga on the plateau. Guided by the Indian canoemen I followed for a day along this trail, first over large alluvial tracts laid down by the Napo in its earlier development, then

over ever more broken ground cut by numerous streams, always keeping within sound of the river. In the evening we came to where the Napo issues



Sketch-map of part of the Ecuadorian Andes

in an impetuous swirl of mad water from the wall of mountains through deeply carved canyons of granite. The sight is imposing in the extreme. We slept that night in a shelter of palm leaves supported on a framework of sticks

which the Indians constructed in a remarkably short time; in the morning we turned back again towards Napo village.

Several days later I set off for the Payamino river, a tributary of the Napo which enters the main river some 90 miles below Napo village. It was somewhere near the junction of the Payamino and Napo rivers that Gonzalo Pizarro and Francisco Orellana constructed the boat with which the latter sailed down the unknown waters to the Amazon and onward to the Atlantic in 1540. The first part of the journey downstream, from Napo village as far as the mouth of its tributary Arajuno, the river is disturbed by numerous rapids, none of them especially dangerous with good canoemen. Thereafter the river has nothing to disturb navigation but half-embedded driftwood. The vegetation along the river course is of the usual heterogeneous sort encountered in moist tropical zones. On the sloping banks grow many beautiful palms, conspicuous among the larger ones being *Mauritia* sp., *Iriatea* sp., *Oenocarpus* sp., and *Socrates* sp. In some places the large river flats are covered with secondary growth where Indians or white settlers previously had clearings. Conspicuous in such secondary growth is the Balsa tree (*Ochroma piscatoria*), probably the lightest of all woods, and much employed by the natives for the making of rafts. The river where it is confined to a single course broadens from some 200 or 300 yards near Napo village to some 500 or 600 yards near the mouth of the Payamino. The south bank of the river below the mouth of the Arajuno is given over entirely to an unsubdued and murderous tribe of Indians, called by the Spanish-speaking people "Infieles," or pagans. This tribe still live in the Stone Age, using weapons and tools of wood and stone and going unclothed. They hold no intercourse whatever with other tribes or with white people, and their ambition seems to be to murder any person who may enter their domain. Owing partly to the fear inspired by these Indians and partly to economic reasons, the upper Napo, which once had a number of more or less populous settlements with numerous haciendas, is now almost deserted. The villages shown on old maps at Ahuano, Napoteo, Santa Rosa, and Coca no longer exist.

The main Napo river has been visited by a number of travellers, amongst others by James Orton, Gaetano Osculati, R. Payer, Hamilton Rice, and Sinclair, but, as far as I am aware, the Payamino country has never before been described or mapped.[1] We spent five weeks exploring the tributaries of this river, the Punino and the Paugiyacu, and we ascended as far as the so-called Pueblo on the main stream. The lowlying banks of the lower Payamino and its tributaries are covered with a dense mass of bamboos which make passage through them almost impossible because of the wicked thorns which grow from the stems and the trailing branches. There is but a handful of population, not more than fifteen Indian families in the whole district, and it was the only place in my travels where I encountered a plentiful supply of fish and game. Most conspicuous of the animals was the tapir (*Tapirus americanus*), whose tracks were everywhere. We several times encountered one of these unwieldy animals swimming a river or ploughing its way through the dense growth along the banks. Forest deer (*Cervus virginianus*) are numerous, as are also two

[1]The author does not seem to be aware of G. M. Dyott's account of the neighbourhood in his 'On the Trail of the Unknown' (London, 1926).—ED. *G.J.*

species of wild swine (*Dicotyles labiatus* and *D. torquatus*). The guatusa (*Dasyprocta Aguti*) is the most common of the smaller animals with the exception of monkeys, of which there are half a dozen varieties, all of the smaller kinds. On numerous occasions we passed the tracks of a puma or of a jaguar, but we did not see the animals themselves. In the rivers we saw a number of bufeos (*Manatus americanus*), a species of small turtle called in Spanish *charapas*, and occasionally an otter. The most plentiful of the gamefowl was the *pava* or wild turkey. Less plentiful was the paujil (*Uvax pauxi*) and the pacharraca (*Crax* sp.). There was a species of partridge and a running wildfowl called in Spanish the *trompetero* from the trumpet-like note it sounds. Of the parrot family there were numerous species, from the gorgeously plumaged guacamayos (*Ara avarauna* and *Ara hyacinthinus*) to the periquetos (*Psittacula* sp.). Of snakes, the most common amongst the poisonous kinds was the *equis*, and amongst the constrictor type, the *amaron*. Neither kind however was plentiful.

The Payamino Indians are of the group of Napo tribes, but they differ in several respects from the Indians of the upper Napo river. The latter people will eat almost anything, while the Payaminos are comparatively fastidious. They will not touch any kind of reptile flesh, refusing even that of the turtle, nor for some obscure reason will they eat venison. They profess christianity, and the priests from Archidona and Tena pay them occasional visits. Their houses are usually built to accommodate several families, and are constructed of palm poles with roofs of thatched palm leaves or reeds. The sides are sometimes left open, sometimes enclosed with bamboo strips. Occasionally rough bunks are constructed for sleeping, but more often a few strips of bamboo are laid on the floor on which to rest. The household utensils are of the crudest and consist of a few locally made earthenware pots and some gourds. The fireplaces are constructed of three stones set in a triangle, and each family in a house maintains its own hearth. The Indians possess the unpleasant habit of burying their dead before their house entrances and at the shallowest of depths. In the Pueblo of Payamino there had been several recent deaths, a fact which the evidence of our noses did not allow us to forget. The chief hunting weapon of the Indians is the *pocuna*, or poison blowpipe. No male adult is without one of these, and even the boys make miniature ones with which to practise. The Indians are very fond of pets, and in every house there were a number of tamed birds and animals, chiefly parrots and monkeys.

With the exception of a few nights spent in Indian houses, during the whole trip we slept in shelters constructed by the Indians in the manner already described. So well do they weave the leaves for the roofs that they will turn the hardest rain, and they built the huts almost as quickly as one could put up a tent. After finishing my work on the Payamino we returned to Napo village, taking seven days of hard poling to ascend the stream. I rested there about a week in a house kindly lent to me by Mr. Larson, the American missionary at Tena, and then again prepared to set off, this time to the south by way of the river Anzu. It might not be out of place to mention the hospitality and kindness I encountered from the white inhabitants in the Napo district, and indeed at every place I touched where there were people of European descent.

One of the great difficulties of travel in the Oriente is in the matter of securing

transport. The Indians dislike departing from custom as regards route and the time to be taken on it. They insist always on being paid in advance, and by the trip, not by the number of days. From each settlement they have a recognized point to which they will journey; beyond they will not go, and so one has to secure a new set of carriers or canoemen every few days, a matter which at the best is difficult and at the worst practically impossible. They object to time being spent on the way in excess of the usual amount necessary, and their method of showing dissatisfaction is to disappear quietly in the night leaving the traveller stranded with his equipment. We were delayed four days by high water in the Napo river, a very usual occurrence in the rainy season from April to July. Finally, on May 19, we started for the Anzu river, fighting our way with great difficulty up the swollen stream. The Anzu enters the Napo river a few miles above Napo village and is navigable to the confluence with its tributary, the Ila, with no great trouble, thence to the mouth of El Junia river with increasing difficulty. It took two days of hard poling for our Indians to bring us to El Junia. We passed several haciendas on the banks of the Anzu, one stocked with several thousands of cattle at a point called Satzayacu. The worst enemy to cattle in those parts is the vampire bat (*Phyllostoma*). From El Junia we continued on foot for three days over an incredibly bad track to Puyo, on the river of the same name. The mud was even worse than it had been on the trail from Baeza to Archidona, and we arrived at Puyo completely worn out.

The maps of this district are very inexact. They show the headwater streams of the Cururay and Bobonaza rivers as rising in the spur of the Eastern Cordilleras called the Llanganates. The Anzu river flows right across the whole of the eastern side of these Llanganates, and has its source at their southern extreme, where also rise in the close vicinity the Arajuno and the Puyo rivers, the last a tributary of the Pastaza. No tributary of the Cururay nor of the Bobonaza rises in the Llanganates. These mountains are hills of mystery; they are the least-known portion of the Ecuadorian Andes, and are credited by legend as being one of the storehouses of the Inca wealth. Richard Spruce, in his 'Notes of a Botanist on the Amazon,' recounts the story of the treasure believed to be hidden in their fastnesses.

Puyo is a village of some fifty white people, outpost of the immigration which is pushing down from the mountains over the mule track completed in recent years to Mera at the foot of the mountains. The last-named settlement is one day to the west of Puyo by an execrable road. Sugar-cane is the chief cultivation in the district, and a kind of unrefined sugar is prepared from it. However, as in other parts of the Oriente, there is no economic outlet for produce, and until a railway can be built into these fertile lands it is hard to see how they can develop. From Puyo we descended by way of the Pindo and Puyo rivers to Indillama, where the trail which leads eastwards to the Bobonaza river is encountered. The Pindo and the Puyo streams I would have left severely alone had I realized their dangerous character. The Indians with me were superb canoemen, and they seemed to experience nothing but sheer delight in careering between jutting boulders and exposed outcrops, but however much pleasure I might take in seeing the dexterity and grace with which they held the racing canoe from imminent disaster, the knowledge that all my money,

instruments, etc., would almost certainly be lost in the event of the craft capsizing, not to mention the danger to life, held me in a state of suspense for the whole three-and-a-half hours of the journey. There is a bush path from Puyo to Indillama which should be used in preference to the river route, at least for the transport of articles of value. From Indillama we headed east towards Canelos on the Bobonaza river. The road leads for a great portion of the way along the narrow points of ridges which run between deeply eroded watercourses. So highly and regularly banked are these ridges that one has the illusion of walking on elevated roads over embankments made by human hands. The display of palms in this section is more abundant than at any other part I visited. Besides all those encountered on the Napo river, there were a great number of chambira (*Astrocaryum* sp.), from which the natives weave a most durable rope, of *Oenocarpus* sp., and of the vegetable ivory (*Phytelephas macrocarpa*), which last is not a true palm. Wild cocoa trees (*Theobroma cacao* and *T. beidos*) were plentiful, and in the valley of the Bobonaza the Para rubber tree (*Hevea brasiliensis*) appeared occasionally. The last few miles before reaching the Bobonaza, the ground falls steeply in a series of escarpments, and one obtains glorious views across the Amazon plains. As Canelos is reached, the eye is charmed with the appearance of a park-like expanse of meadow land where the Catholic priests have cleared a stretch of the river bank as pasture land for their cattle.

The Indians of the Bobonaza speak the same Quichua language as those on the Napo river. They are taller and more energetic than the Napos however. They take a delight in painting their faces and portions of their bodies black with the juice of *huito* seeds, relieved by patterns in brilliant red on their cheeks and foreheads. They have a more definite manner of clothing themselves than the Napos, and, unlike the latter, live in villages for at least a portion of the year. While in the villages they wear long trousers and a short shirt coat, always dyed black. Around the neck they wear a band of woven beads about an inch and a half wide, and around the wrists they wear somewhat similar bands of woven coloured threads. They are christians, but at the same time they have the reputation amongst neighbouring tribes of practising a very potent witch-craft, which is much to be feared. They usually possess two houses, one in one of the large villages on the river bank at Canelos, Parcayacu, or Sarayacu, and another hidden away in the forest. They are very clever at the manufacture of earthenware pottery, of which every house possesses a plentiful supply. There are no white settlers on the upper Bobonaza other than several priests and brothers at Canelos and one family at Parcayacu.

We descended the river for two days as far as Sarayacu, then returned upstream to the tributary, the Curiyacu, where we took an Indian path to the Cururay river. The country between the Bobonaza and the Cururay is a much dissected peneplain, some 600 feet above the level of the river valleys. The formation is of sandstone and shales. As in most of the Oriente, animal and bird life is scarce. The natives kill everything, young or old, that they can get within range of with their poisoned darts, and to a lesser extent with muzzle-loading guns, and this slaughter, carried on by succeeding generations, has resulted in a dearth of game of all kinds. After spending some two weeks in the headwaters of the Cururay, we returned to Canelos. The Bobonaza river

offers one of the easiest routes from Eastern Ecuador to the main Amazon river. There are few rapids, and none of them are bad ones. Below Sarayacu, with the exception of some shallows in the dry season, there is no hindrance to navigation with large canoes. A few days below Sarayacu the Bobonaza empties into the broad Pastaza, in that portion a peaceful stream, navigable by steam launch to where it joins the Amazon and thence to Iquitos. From Canelos we returned once more to Indillama with the intention of continuing towards the south. The southern portion of the Oriente, although it has been visited by Europeans, has been singularly little described. We left Indillama one early morning, and two hours later arrived at the Pastaza river, at that point an impetuous torrent which can only be crossed in its good moods. Luckily it was in such a mood when we arrived, and with the help of an Indian living at the crossing, we landed safely on the other side. Two days' walking over the usual bad trails brought us to Alapicos, a settlement of a handful of white people on the high banks of the swift Palora river. The country on the route is much cut up by rapid streams, and at least one of the many we had to ford, the Yanamanaca, would be impassable in even a moderate spate.

Arapicos is the boundary between the Quichua-speaking and the Jibaro tribes. The Jibaro nation was one of the few to defy successfully the might of the Conquistadores, and to this day they acknowledge only the shadow of authority to the Ecuadorian Government at points near the few white settlements, and away from these settlements none. They are an intelligent and active people, well formed and athletic of build, and of a most independent spirit. They have been called headhunters because of their custom of cutting off the heads of enemies killed in their intertribal warfare. These heads they afterwards reduce by a process peculiar to themselves to the size of large oranges, after which they hold a feast of victory in which the reduced heads are the material symbols in a ritual which is the expression of their confused animistic beliefs. Men and women wear the hair long, and it is not always easy to distinguish between the sexes, the more so that both wear short skirts of home-woven cloth with indeterminate garments covering shoulders and breasts. The married women usually have a short portion of stick, the size of a small skewer and about 2 inches long, thrust into a hole bored for the purpose below the lower lip. The men wear longer and larger sticks thrust into holes in the lobes of the ears. These sticks are often decorated with painted or carved patterns. The men carry in the hair strings of brilliantly coloured beetles' wings and brightly hued feathers. The women are seldom prepossessing and occupy a minor position in the family unit. The ceremonial conversations, which are always preliminary to ordinary intercourse when entering a Jibaro household, have a peculiar ritual. The visitor, on first entering, is scarcely glanced at by the host, and sits down as inconspicuously as possible. After chicha is offered by the women and accepted, the host suddenly turns to the visitor and commences a vehement string of short sentences, which the addressed man constantly interrupts with violently affirmative interjections. During the conversation each man holds the cupped palm of the hand over the mouth, only removing it occasionally to gesticulate fiercely. The whole conversation sounds more like a fierce quarrel, with each man trying to shout the other down, than a friendly exchange of words. After it has continued for

anything from half an hour to an hour, it ceases as suddenly as it began, and thereafter an ordinary tone of voice is employed in speaking. The extent to which the continual death feuds affect every custom of the Jibaros' daily life is soon realized. The men are never found far from their weapons, and when in the bush they are ever ready on the slightest suspicious sound to slink away into the thicket with their guns held ready for instant action. The large communal houses are fortified by walls of hardwood poles with closely secured doors. It is with great difficulty that the men are induced to go even a day or two's journey from their homes, the unfailing excuse being that they will be killed on the way by their enemies. Every death amongst them is set down to the machinations of the witch doctors of their foes. There is probably scarcely a grown man amongst them who has not had actual experience in murder raids. These raids are always carried out by ruse and treachery in darkness or semi-darkness, and never by open assault. Their weapons are the muzzle-loading gun and the lance, the latter sometimes being surmounted by an iron tip and sometimes being made entirely of the hard wood of the chonta palm. They use the poison blowpipe for hunting, but for some reason it is not employed against human enemies.

I obtained carriers from Alapicos to Macas, the next stage of my journey, with the greatest difficulty, but finally, after crediting a letter I held from the Government at Quito with an authority it had never meant to convey, succeeded. The Palora river has carved out a valley of interwoven channels and gravel bars about a mile wide and several hundreds of feet beneath the level of the surrounding country. Looking up this broad valley one gets a magnificent view of the beautiful volcano, Sangay, most symmetrical of all the Ecuadorian peaks. We waded the minor channels of the river and came to the main stream, a rushing torrent across which we had to make repeated journeys in a small canoe before we had carriers and loads all on the south side. The road onwards to Macas, three days distant, is through country broken with deeply cut rivers, two of which, the Tunichigwasi and the Chigwasi, are really dangerous to ford. Macas is an isolated settlement of white people, widely separated from civilized centres. Its situation on the banks of the Upano is very similar to that of Alapicos on the Palora. Macas however has a population of six or seven hundred people of more or less white blood. The foundation of the settlement is laid in the tragic history of Sevilla del Oro, destroyed with its sister cities by the Jibaros in 1599. The reason for the Jibaro revolt was the Spanish Governor's thirst for gold, to assuage which the Indians tied him to a post and poured a stream of the molten metal down his throat. Long after the revolt the settlement of Macas was founded near the supposed site of the destroyed Sevilla del Oro. The people have kept their blood much purer than is commonly the case in Ecuador. Many have fair hair and blue eyes with no trace whatever of Indian blood in their features. The climate is healthy, and the only endemic disease, apart from the ordinary ills of mankind, appears to be a form of melanism. The surrounding country is a raised plain of volcanic breccia, exceedingly fertile and set in a situation of great natural beauty. To the west rise the great peaks of the Andes, to the east lie the Upano hills, and to the south the eye finds no limit to the great plains.

Three days' trek to the south over the usual vile roads brought us to Mendez

on the Paute river. The road follows more or less the course of the Upano river, which a few miles below Mendez is joined by the Paute to form the Santiago. Some maps show the Upano as flowing into the Macuma, an error as great as though the Thames were shown as emptying into the Humber. Neither the Upano nor the Paute can be navigated by canoe. A feature of the bush along the banks of the former is the amount of wild coca encountered. Before reaching Mendez the road leaves the course of the Upano and climbs a quartzite spur of the foothills which runs into the apex of the two streams. Mendez lies in a deep valley shut in by high hills. It is connected by mule track to Cuenca in the mountain plateau and has a population almost entirely comprised of gold-washers who have come down to wash the rich bars of the Paute river. The river lies directly before the settlement, a swift stream some 150 yards in width. My next objective from Mendez was the junction of the Zamora and Santiago rivers, the least-known portion of all the country I visited. It was once again with the greatest difficulty that I secured carriers for the journey. There is nothing in the way of a trail beyond Jibaro hunting tracks, known only to the Indians, and the broken country is cut by one precipitous river after another. I finally secured several Jibaros who consented to carry my greatly reduced loads, and we set off for what I was informed would be a four-days' journey to arrive at the junction of the two rivers.

After six days' wandering over Indian trails, never quite sure if we were going in the right direction or not, we finally arrived at the junction of the two great rivers. The valleys through which they run are some 600 feet in depth, and to get to the water's edge we had to clamber down a precipice of several hundreds of feet, an impossible task had it not been for the creepers and the roots which found crevices in the volcanic breccia walls in which to take hold. As far as I know, I am the first European to arrive at this spot by land. The Indians in this district live almost as they have lived since before the advent of the Spaniards, the only indispensable article of white manufacture for them being the muzzle-loading gun. Truly impressive is this junction of the two broad sheets of swift water rushing between shorn walls of rock strewn at the base with great boulders. The water, shadowed by the high forested banks, seems dark and gloomy, and it was with a feeling of relief that I arrived once more at the top of the cliffs and left the rivers behind. We then headed towards Indanza, a settlement after the type of Mendez, on the banks of the Indanza river, a tributary of the Zamora. Our Jibaro guides led us by hunting paths over a volcanic country cut by innumerable streams, and after three days of most tiring travel we arrived at our destination. At Indanza I was able to secure an old mule to carry the little kit that remained with me over the break-neck trail to Cuenca. I myself with Pancho, cook, interpreter, and companion over the whole journey, trudged painfully behind between mountains of schist up the pathway ascending to the pass, and three days after leaving Indanza we arrived at Cuenca and civilization on July 18, four months after we had set out from Quito.

THE HUMAN GEOGRAPHY OF THE FENLAND BEFORE THE DRAINAGE

H. C. DARBY

THE main story of the formation of the Fenland depression is fairly clear. There was a time before the Ice Age when the Chalk Uplands of Lincolnshire were continuous with those of Norfolk, and through gaps in this chalk ridge there flowed eastward the early representatives of the modern river-courses. This ridge disappeared under the action of two forces.[1] The river-gaps, enlarged by the normal processes of erosion, reduced the one-time escarpment to little more than a line of isolated outliers, while the submergence of the land completed the work so that the sea gained access to a western plain formed by the outcrops of soft Jurassic clays. The Fenland in its origin was essentially a flooded alluvial plain which had for its limits the harder rocks around, chalk to the north and south and, in the west, resistant oolite grits. The surface of this Jurassic plain was uneven, and in its higher portions projected above the general level to form the "islands" of the historical period, Ely, March, and so on. The region emerged from the complicated events of the Ice Ages with its basin character unchanged, and all subsequent time has witnessed its filling up by the various agents of sedimentation—normal and otherwise—leaving the Wash of the present day as the remnant of a much wider opening of the sea. The mediaeval registers often record additions of "silt or sand" which owing to the "seas leaving thereof, become firm ground,"[2] thereby yielding an increase of land surface.

The boundary of the depression thus formed may be defined by a line running from Firsby through Tattershall to Lincoln, and then by Billinghay and Peterborough almost due south to Earith, whence it curved northward through Cottenham and Burwell to Lynn. The regularity of this line was broken by the extension of fen up the rivers that, leaving the surrounding upland, wandered slowly[3] through the plain by devious[4] channels and "sundry branches"[5] before they reached the sea. The chief of these were the Ouse, the Nene, the Welland, and the Witham; the modern drainage system is almost entirely artificial.[6] The sediments carried down by these streams and deposited where their velocity was checked, or brought up-channel by the tides from the sea oftentimes so "filled up with silt and sand"[7] the river-courses that their waters were forced to seek new outlets, winding back upon themselves maybe or interlacing with other streams. Such was the case in the Wisbech estuary which during the thirteenth century was filled up by "silt and sand brought in by the sea-tides," until a mere slender stream flowed out to sea leaving a great stretch of marsh on either side; thus Wisbech, the point of discharge for

[1] For the geology see S. B. J. Skertchly, 'The Geology of the Fenland,' 1877.

[2] Dugdale, 'History of Embanking and Draining (1662),' p. 235, quoting the Peterborough Register, 1342.

[3] 'Chronicon Abbatiae Ramesiensis' (Rolls Series), p. 8.

[4] 'St. Guthlac,' ed. Goodwin, p. 21.

[5] Dugdale, *ibid.*, p. 176.

[6] For the old river-beds, see Gordon Fowler, *G.J.*, vol. 79, 1932.

[7] Dugdale, *ibid.*, p. 323.

much fenland water, was deprived successively of the Ouse and the Nene, which sought an outlet through Lynn. Oftentimes the streams completely lost their definite courses or broke their banks and spread out "into black pools" (the numerous "*gurgites*" or "*stagna*" of the manorial rolls[1]) "as much as two or three miles in breadth"[2] or into "deep and boggy quagmires in breadth about two bow-shot"[3]; and the Fenland as a whole was "depicta multis lacubus magnis et parvis."[4] This state of affairs has long disappeared, but as late as 1769 Thomas Pennant[5] could note that:

> The East Fen is quite in a state of nature and gives a specimen of the country before the introduction of drainage: it is a vast tract of morass, intermixed with numbers of lakes from half a mile to two or three miles in circuit, communicating with each other by narrow reedy straits; they are very shallow, none above four or five feet in depth.

The areas covered by water increased considerably in winter time. On the one hand the rivers, "charged with fresh waters coming down from the"[6] uplands, often broke their banks and spread over the adjoining land.[7] Along the banks of the Welland "there was so much water in winter time that it covered the ground an ell and a half in depth and in a tempestuous wind two ells."[8] In a like manner the Witham "caused frequent inundations to the lands adjacent."[9] For instance, in the year 1467

> in the month of January there was so great an inundation of the waters, by reason of the snows and continued rains, that no man living in our times could recall to mind the like. Throughout the whole of this county, and in Hoyland especially, there was scarcely a house or building, but what the streams of water made their way and flowed through it. Nor must you suppose that this happened hurriedly and in a cursory manner only: but continuously, during a whole month, the waters either stood there without flowing off, or else, being agitated by strong gusts of wind, swelled and increased still more and more day after day.[10]

On the other hand there were incursions from the sea. "But these irruptions of the sea, as they were casual (viz. when the north or north-east winds accompanied extraordinary spring tides) so were they not frequent, nor did those floods so long continue upon the land as to destroy it by drowning; the stagnation of the fresh waters producing much more damage."[11] Yet the salt floods were bad enough and continued to do damage well into the seventeenth century. An inscription,[12] now obliterated, on the walls of Wisbech church told how in November 1613:

> the sea broke in, through the violence of a north-east winde, meeting with a spring tide, and overflowed all Marshland, with this town of Wisbeche, both in the north side and the south, and almost the whole hundred round about, . . .

[1] Littleport Rolls in the *Proc. Cambridge Antiquarian Society*, 1878, p. 97.
[2] 'Memorials of St. Edmund's Abbey' (Rolls Series), p. 13.
[3] 'Ramsey Chronicle,' *ibid.*, p. 8.
[4] 'Henry of Huntingdon: Historia Anglorum' (Rolls Series), p. 165.
[5] 'Tour in Scotland,' 1774, p. 10.
[6] MS. Volume in Wisbech Museum, p. 107.
[7] Ingulph, 'Historia Croylandensis' (ed. Riley), p. 156.
[8] Dugdale, *ibid.*, pp. 212–13.
[9] Cal. Patent Rolls, 6 Ed. iii.
[10] Ingulph, *ibid.*, p. 443.
[11] Dugdale, *ibid.*, p. 299.
[12] *Ibid.*, p. 276.

Surface deposits of the Fenland and distribution of Domesday Vills

Records of floods from both land and sea occur again and again in the annals of the Fenland, and when Isaac Casaubon visited Ely in 1611 the scene that presented itself to his view was of "a marshy place which is covered for the most part by water throughout the winter."[1]

For these reasons therefore much of the Fenland long remained a wilderness of reeds and rushes,[2] relieved only by woody thickets upon the low eminences, a desert place where at first no man dwelt. The Romans had attempted to drain the Fens by constructing causeways and throwing up embankments along the shore, but after the Roman departure from Britain the region again became waterlogged and in the main continued so until the seventeenth century. An early eighth-century Life of St. Guthlac[3] thus described the area at the beginning of the Middle Ages:

> There is in Britain a fen of immense size, which begins from the river Granta not far from the city, which is named Grantchester. There are immense marshes, now a black pool of water, now foul running streams, and also many islands, and reeds, and hillocks and thickets and with manifold windings wide and long, it continues to the north sea. When . . . Guthlac . . . inquired of the inhabitants . . . they told him many things about the vastness of the wilderness. There was a man named Tatwine, who said that he knew an island especially obscure, which ofttimes many men had attempted to inhabit, but . . . on account of manifold horrors and dears, and the loneliness of the wide wilderness . . . everyone . . . had fled from it.

Despite these general features however the Fenland was far from being uniform in its aspect. Geologically it fell into two distinct regions of approximately equal size. The true Fenland or peat area was separated from the coast by a wide belt of silt, the transition from one to the other being remarkably abrupt.[4] This topographical variation had its human counterpart, for distinct types of settlement were developed in each of the two areas.

The peat land averaged less than 10 feet in height above sea-level and presented a surface as smooth as that of the water.[5] Settlement was prohibited here because the soil provided no stable foundations on which to build. Even those portions that escaped winter flooding were subject to an annual heaving motion, as the peat absorbed water and swelled. Consequently not one village was situated in all this area, with the sole exception of Benwick, and here only because a local gravel substratum approached within a few inches of the surface. In the period immediately before the drainage the houses of Benwick were "omnes ut *περιρρύτους* insulas."[6] But above the level of this plain, especially in its southern parts, were the islands of Jurassic rock "which," a pious monk records,[7] "God of purpose raised (as may be thought) to be habitations for his servants, who chose to dwell there." During the seventh century Christianity was replacing Paganism in England, and the Fenland was

[1] Casaubon, 'Ephemerides' (ed. J. Russell), 864–5.
[2] 'Ramsey Chronicle,' *ibid.*, p. 8.
[3] 'St. Guthlac' (ed. Goodwin), p. 21.
[4] On the surface this is so, but vertical sections reveal a different state of affairs due partly to the conflict between fresh and salt waters and partly to alternating periods of accretion and marine denudation. See Skertchly, 139.
[5] Malms. G.P. 326.
[6] Casaubon, 'Ephemerides,' pp. 870–1.
[7] Dugdale, p. 178.

to benefit greatly by this movement, for "these marshes afforded to not a few congregations of monks desirable homes"[1] severed from the world, and the early mediaeval chroniclers record how in the "midst of a wide wilderness" successive monasteries arose. The marshes surrounding these monasteries were enclosed and converted into "good and fertile arable land"[2] and the peat fen was dotted with centres of reclamation. The 'Historia Croylandensis' provides typical details. In the dry seasons naturally there was an increase in fen pastures, and towards the close of the tenth century the marshes to the north of Croyland were put "into a state of cultivation in four places" during some years of drought,[3] while a century later a mighty work was undertaken by Richard de Rulos.[4]

> He excluded the river Welland by a very strong embankment, because every year it had, by its continual inundations, overflowed nearly all the meadows adjoining the banks of the said river; from which circumstances that vill, had in ancient times, received the name of Depyng meaning the "deep meadow." Building upon the embankment numerous tenements and cottages, in a short time he formed a large vill, marked out gardens and cultivated fields; while, by shutting out the river, he found in the meadow-land which had lately been deep lakes and impassable marshes, most fertile fields and desireable land, and out of sloughs and bogs accursed made quite a pleasure garden. Having thus formed a most fertile soil he at the same time changed the said Chapel of Saint Guthlac into the parish church of his new vill.

This example stimulated further effort[5]:

> In the following summer, (1085) the people of Hoyland at Multon, Weston and Spalding, in imitation of those at Depyng . . . divided among themselves . . . their marshes which were situate above our river Asendyk; on which, some put their portions in tillage, others preserved theirs for hay, while some again allowed theirs, as before, to lie for pasture for their own cattle apart from the others, and found the earth to be rich and fruitful.

Operations of a like nature continued down the centuries; nor were they confined to ecclesiastics. Associated with these efforts was the building of causeways through the fen. In the year 1050[6] it is recorded how the first of these was made by a monk of Peterborough who

> caused a solid highway for travellers to be made through the middle of most dense forests and the extremely deep marshes of Depyng as far as Spalding, constructed of timber and sand; a most costly work and one of the greatest utility.

As time went on more of these causeways were built, the details of their courses being governed by the disposition of the bluffs and spurs that occurred in the marsh. The difficulties involved in such works may be judged from an entry in the Patent Rolls for the year 1337,[7] in which it is stated that:

[1] 'Memorials of St. Edmund's Abbey,' vol. ii, p. 13.

[2] Ingulph, p. 275. It is impossible to be sure of the truth of much that is contained in the history ascribed to Ingulph (see Riley, *Archaeological Journal*, xix, 34–49, 114–133); but evidence that the marshes of Holland had been drained is provided by the trustworthy second continuation of Ingulph, p. 275. See also the Domesday entries for Deeping.

[3] *Ibid.*, p. 107. Cf. p. 170. Marshes let out for the purposes of cultivation.

[4] *Ibid.*, p. 156.

[5] *Ibid.*, p. 193.

[6] *Ibid.*, p. 129.

[7] Cal. Pat. Rolls. 1337.

> . . . between the great bridge at Croyland and le Brotherhous, where the dangerous part of the way is, there are three miles (leuce) of marshy land along the bank of the Weland, on which it would be difficult to make a causey, inasmuch as, the land lying deep in a morass, the causey would have to be by the sand bank and, since the bank is liable to be flooded in winter, the land whereon it would be made is at such times greatly loossened, as well by the passing of sailors and boatmen as by the forces of the wind, and falls away to such an extent that any causey on it would be destroyed, unless deep and high and well protected; that for the convenience of the people of those parts there would also have to be several bridges over the river Weland both at Croyland and across the causey, which must be built at great cost to be high enough for laden ships and boats to pass under them, and strong enough for carts to pass over them.

The adjoining or neighbouring parishes were held responsible for the repair of these ways "as often as need should require so that the passage of travellers might not be hindered."[1]

The silt land occupied the north and central parts of the Fenland, bordering on the Wash; the soil was clayey and silty and the surface of the land was somewhat uneven, averaging about 15 feet above sea-level. Less liable to annual flooding, except on its seaward margin, and composed of a substance more solid than fen peat, the region offered better opportunities for continuous settlement. The distribution of village sites in Domesday times indicated the area as a belt of uniformly occupied territory joining the uplands of Norfolk and Lincoln, and separating the sea from the peat fen. But the occupation was not only different in quantity, it was different in nature from the nucleated vills on the southern islands or on the upland around. Here, in the silt zone, rural settlement was definitely of the dispersed type. As the rivers and dykes themselves provided a water supply, there were no concentrating factors of well and spring. Moreover the régime of economic life in the region was not favourable to compact settlement. What with fishing and fowling, meadows and turbaries, the individual's resources were more widely disseminated than in the normal community, and Stenton[2] declares that "the Saltfleetby charters as a whole produce the impression that holdings were small and often compact, that dwellings were dispersed over the whole village territory"; some of the houses of Wisbech were "in distance from the Parish Church some four miles or more," and there are many examples of dwellings standing alone in "half an acre of marsh."[3]

Before the end of the thirteenth century the dispersal of houses had led to the division of the Saltfleetby tenantry into three parishes. The whole silt zone is full of similarly divided parishes. Such are Terrington, Wiggenhall, Sutton, Walpole, Wainfleet, and Tudd. Wiggenhall, for example, has four divisions: Wiggenhall St. Mary the Virgin, Wiggenhall St. German, Wiggenhall St. Peter, Wiggenhall St. Mary Magdalene. An incident[4] in the early years of the fifteenth century may provide a hint as to the process of subdivision. In 1401 the inhabitants of Eastrea obtained a licence to build a chapel because they could not attend the parish church by reason of the inundations. In 1406 they

[1] Dugdale, p. 214 (1351).
[2] 'Document Illustrative of the Social and Economic History of the Danelaw,' p. xxxix.
[3] Stenton, p. 550. Cf. Ramsey Cartulary, i, 362, and Wisbech, MS. volume, p. 107.
[4] *Jour. Archaeol. Assn.*, 1829, p. 269.

secured a further licence to absent themselves from the celebration of mass in the parish church of Whittlesey and to have a celebration in their own chapel.

The inhabitants of the silt zone, like those of the peat fen, "with draining and banking, won as much thereof by their industry as they could."[1] So great was the progress made by these and kindred works that by the middle of the thirteenth century Matthew Paris[2] could declare that a miracle had happened in his own time: that which was formerly inaccessible marsh abounding in reeds was now converted into delightful pastures and arable fields. Hence those encomiums lavished by the monkish chroniclers upon the Fens, upon Ely "of fairest place," upon Ramsey, "most beautiful isle," and upon Crowland "a very Paradise." Mediaeval descriptions of the Fenland oscillate between praise of its beauty and fertility on the one hand and warning of its inhospitable character on the other.

Deeds of gift or exchange within the Fenland area normally concluded with a statement of right:

> to enjoy the same in wood and in plain, in meadows and in pastures, in waters and in marshes, in preserves and in fisheries, in mills and milldams and in all other things.

Such were the products and resources of the unreclaimed fens. Not only cultivation and grazing but fishing, fowling, and the gathering of peat and sedge and salt provided the foundations of Fenland economy, and maintained a local habit of life quite different from that in the normal mediaeval community. Here was a peculiar mode of existence whose characteristic occupations continued right up to the period after the drainage. The description given by Hugh the White,[3] a monk of Peterborough in 1150, agrees substantially with that given by Drayton[4] in his 'Polyolbion,' published in 1622. Drayton's general picture is one of very varied activity:

> The toyling fisher here is tewing of his net:
> The fowler is employed his lymed twigs to set.
> One underneath his horse to get a shoot doth stalke;
> Another over dykes upon his stilts doth walke:
> There other with their spades, the peats are squaring out,
> And others from their carres are busily about,
> To draw out sedge and reed, for thatch and stove fit.

The products gained as a result of such industry were of three kinds: those of the marsh itself; those of the intermediate zone of grazing, flooded for a part of the year; and lastly those of the arable land which remained permanently above the water-level. These may be considered separately.

The allusions in the early fourteenth-century Manor Rolls of Littleport[5] show that the vegetable product of the marsh itself consisted almost entirely of "lesch," a term which not only denoted sedge and all the *Carices*, but which may have included reeds and rushes as well. "Lesch" indeed seems to have fulfilled many of the uses of money among the Fen men; they were habitually owing or being owed so many "thousands of lesch." It was the same three

[1] Dugdale, p. 244.
[2] 'Chronica Maiora' (Rolls Series), 1256.
[3] 'Historiae Anglicanae Scriptores' (ed. Sparke), pt. iii, 2.
[4] 'Polyolbion,' p. 442.
[5] *Proc. Camb. Antiq. Soc.*, 1878.

centuries later, when Camden[1] noted how "this tract abounds likewise with ruf and sedge for firing, reeds for thatching, alders and other aquatic trees, especially willows, which the soil particularly suits."

As late as 1782 there is a description[2] of reed-cutting:

> The cutters have a boat to carry them from the bank to the "reedpond"; which, in this case, lies at a small distance from the shore. Some they cut standing in the boat; some standing on a plank, laid partially, or wholly, upon the mud and roots of reed, matted intimately together. The workmen cut it upwards, gathering the reed in the left hand and arm, underhanded, with sickles (reaping hooks are too slippery for the reed) as much below the water, consequently as near the root as may be; it being an idea, even unto a proverb, that one inch below the water is worth two above it; . . . Having encumbered their boat, they push it to the shore, and make the reeds up into sheaves . . .

Throughout the mediaeval period there were many references to the cutting of lesch[3] out of season and not a few mutual arrangements to prevent this. Thus in 1415 it was agreed that

> the said vills of Spalding and Pynchbeck shall take rushes and reeds at reasonable and competent times in the year. And after the said rushes and reeds shall have been cut by them, at a competent and reasonable time, they shall carry them beyond the said marsh called Goggislound, but upon the understanding that the fisheries of the said abbot of Croyland, in the said marsh, shall in no way be injured by the long standing of the said rushes and reeds.[4]

During the earlier period reeds seem to have been used for building purposes; houses were made of them and reed thatch always remained an important roofing material. In 1769 they were still a valuable product of the undrained portions of the Fenland, for in this year Pennant[5] tells how "the fen is covered with reeds, the harvest of the neighbouring inhabitants who mow them annually; for they prove a much better thatch than straw and not only cottages but a good many houses are covered with them."

In summer the fenmen cut turf[6] not only for "the erection of their buildings and for the repair and raising of their embankments,"[7] but also, owing to the relative scarcity of wood, for fuel.[8] Great economy was exercised over wood, and care was taken to collect sticks and gather brush wood[9] in the marsh every year. In those parishes situated near the coast salt was another important marsh-product, obtained by evaporating the tidal waters which flowed into the sandpits. The place-names along the coast[10] bear ample testimony to this, and throughout the zone there are an immense number of transactions similar to the grant, soon after 1193, "by William de Roumara to St. Mary and the canons of Dereham of the right of digging with four spades in his marsh belong-

[1] Camden, 'Britannia' (1789 edition), vol. ii, p. 126.
[2] Marshall, 'Rural Economy of Norfolk' (1795), ii, 153.
[3] In the Littleport Rolls.
[4] Ingulph, *ibid.*, p. 385.
[5] *Op. cit.*, p. 11.
[6] 'Polyolbion,' p. 440.
[7] Ingulph, p. 386.
[8] Casaubon, 'Ephemerides' (ed. J. Russell), p. 871.
[9] Ramsey Cartulary, ed. Hart and Lyons (Rolls Series), vol. i, p. 345.
[10] *E.g.* Salter's Road.

ing to Bolingbroke for the repair of their salt pans."[1] Large numbers of these salt pans are recorded in the Lincolnshire Domesday Book; the parish of Bicker Haven alone had no less than twenty. Many inhabitants in mediaeval times paid their rents in salt,[2] and in a volume of 1562 it was said "Much salt is made in England as of sand and salt-water in pits in Hollande in Lincolnshire."[3]

The fisheries of the Fenland constituted another of its most characteristic industries. Indeed, many have suggested that the abundance of fish may have been among the motives that promoted the early monastic settlement of the region. Whether this was true or not, the piscary always occupied an important place in the life both of Fenland monastery and of Fenland village. In 1130 William of Malmesbury[4] declared that "Here is such plenty of fish as to cause astonishment in strangers, while the natives laugh at their surprise. Waterfowl are as plentiful; so that five persons may not only assuage their hunger with both sorts of food, but eat to satiety for a penny." There is scarcely a document relating to the area which does not make some reference to fishing. No less than seventy-seven fisheries are mentioned in the Domesday Book as paying rents in the Lincolnshire fens alone, and the entries for Cambridgeshire indicate that the manor of Wisbech produced over thirty thousand eels annually. Grants of fisheries, or half-fisheries, even of quarter-fisheries; divisions of fisheries into nights and half-nights; exchanges of fisheries for other interests[5]; and the many disputes arising[6] from such transactions; these items occur again and again in the monkish annals. For fish, important everywhere as an article of food in mediaeval times, was nowhere so important as in a region such as this. The Domesday Survey reveals the fisherman as a distinct class in the fens, "the fisherman with his small keels, and his assistants and his nets."[7] The Ramsey Cartulary lists the Abbey fishers as "seven fishermen and their seven families together with their seven ships";[8] while subordinate to the Abbey were fisher-tenants, Alfgar of Hilgay, Hugh the tenant of Wiggenhall, to name but two of a large number.[9] And it was the same in the lands of the other Fenland abbeys; large quantities of fish were exported from the region to other parts of England.[10] The fish were varied in kind, but eels were the most abundant; indeed, were used as common currency throughout the region. Debts were settled by payments of eels,[11] and rentals[12] and tithes[13] were normally defined in terms of thousands of eels. For example, in Wells a rental of sixty thousand per annum fell to Ramsey,[14] and similarly the village of Wylla

[1]Stenton, 'Documents Illustrative of the Social and Economic History of the Danelaw,' p. 526.
[2]Ramsey Cartulary, i, pp. 92, 102.
[3]In Bullein, 'Bulwark of Defence against all Sickness,' 1562.
[4]'De Gestis Regum Anglorum,' ed. Stubbs (Rolls Series), p. 322.
[5]See Stenton, pp. 99, 188, 173, 204; and Ingulph, p. 206.
[6]The 'Historia Croylandensis' is full of such.
[7]'Codex Diplomaticus' (Kemble), No. 581.
[8]Vol. iii, p. 239.
[9]The Cartulary is full of these. See especially vol. iii, p. 289; vol. ii, p. 279.
[10]Wheeler, 'The Fens of South Lincolnshire,' p. 478.
[11]Ramsey Cartulary, i, 99; iii, 298–9.
[12]*Ibid.*, iii, 292; ii, 320.
[13]In Littleport Rolls.
[14]Ramsey Cartulary, ii, 55.

paid some sixteen thousand to Thorney and Peterborough. From the charters of the 'Codex Diplomaticus,'[1] Wylla (Wyllan-ig=Welney) may be pictured as a small island inhabited by fishermen where multitudes of eels were caught. This was but typical of many Fenland isles, for "in the eddy at the sluices of these meres are netted innumerable eels, large water-wolves (*lupi aquatici*), even pickerels, perches, roaches, burbots, and lamphreys, which we call water-snakes. It is indeed said by many men that sometimes Isicii [?] together with the royal fish, the Sturgeon, are taken."[2]

Of the lake of Ramsey[3] it is recorded that

> in the deep and great gulp of which mere, there are frequently taken, by several sorts of nets, as also with baited hooks, and other fishing instruments, pikes of extraordinary bigness, called "hakedes" by the country people: and though both fishers and fowlers cease neither day nor night to haunt it, yet is there always of fish no little store.

Next to fish, fowl was the characteristic item of fen produce. Nesting midst "flags and bulrushes and reed" in such great numbers "that you would think they sat upon the very ground"; and flying "from mere to mere," sometimes so thickly that the very sky was "darkened with their flight,"[4] these birds afforded a livelihood to many inhabitants of the region, and the fowler was a typical Fenland figure. The variety of birds was as remarkable as their quantity. "There are innumerable geese," declared Thomas of Ely in the twelfth century, "fiscedualae [?], coots, didappers, water-crows, herons, and ducks of which the number is very great,"[5] and in the seventeenth century both Michael Drayton and Camden enumerated these at length.

> In winter time when all is overflowed
> And want of solid ground enforceth them abroad[6]

or, declared Thomas,[7] "when the birds moult their quills, I have seen them caught by the hundred, and even by three hundreds more or less, sometimes they are taken in nets and snares as well as by bird-lime." The eggs of the birds were also valuable and collected out in the marsh.[8] The Assize Rolls[9] of the early fourteenth century tell of a boy who went on stilts (*lignipedes*) into the marsh to look for duck's eggs (*ova anatum*) and was drowned. Stilts[10] were indeed a common mode of progression and doubtless the old proverb of "Cambridgeshire Camels" originated in this practice. There were many people who trespassed upon the preserves of others. We may read how in the year 1286 Eustace of Cotes and a certain Goose his fellow were wont to enter the warren with nets and to take plover and such-like wild fowl (*capere plunerios et huiusmodi volatalia*); how Laurence Seman of Cambridge and Thomas

[1] Nos. 563, 578, and 581.
[2] 'Liber Eliensis,' ed. Stewart, ii, 231.
[3] 'Ramsey Chronicle,' *ibid.*, p. 8.
[4] 'Polyolbion,' p. 440.
[5] 'Liber Eliensis,' ii, 232.
[6] Drayton, p. 441.
[7] *Ibid.*, ii, 232.
[8] Littleport Rolls.
[9] Palmer, Cambridge Assize Rolls (*Proc. Camb. Soc.*), 1896. Cf. *C.A.S.*, 1923, p. 209, also.
[10] Casaubon, *ibid.*, p. 871.

Baken of Landbeach and many others did likewise, and how they were caught and tried for their offences.[1]

The annual alteration of the water-level in the fens left free each summer a broad zone most suitable for pasturage, which during the dry seasons increased in size considerably. Portions of this zone were rendered more accessible or kept above water for a longer time as reclamation proceeded around the different centres. By the twelfth century the grazing of animals had become one of the most important occupations within the fens,[2] and in 1252 the cowherd had become a prominent monastic officer with his duties very carefully defined. Grants and exchanges of meadows grew more and more frequent, and at the same time pasture rights assumed great prominence. The earliest extant original charter relating to the fens of Lincolnshire is that of a grant by Earl William of Lincoln to Kirkstead Abbey of common pasture in Wildmore Fen about the year 1140. This importance of grazing continued right up to the final drainage. In the sixteenth century it was recorded of the typical fenland village of Downham that it had "cattle, over four hundred oxen and cows besides flocks of sheep."[3] The meadows seem to have been of every variety, from those but rarely left uncovered by water to those which remained dry throughout the greater part of the year; from those in the "deep marsh" to those in the "dry marsh."[4] Hay was stored for feeding the animals during the wet season. In the year 1189 "the abbot of Crowland in conformity with his usual custom, put his marshlands in a proper state of defence as is usually done each year about the time of the Rogation Days; and proclamation was publicly made upon the bridge of Spalding that the men of Hoyland should prevent their cattle from entering the marsh in order that the crop of hay might have liberty to grow."[5] This must have been "leyt," the coarse sweet grass which was made into fodder for cattle during the time of Camden.[6]

The cattle were normally pastured in common, and in no part of England were common rights so important as in the fens.[7] The forest regions of Leicestershire and Nottinghamshire exhibited the same phenomenon. That is to say, this abnormal economy was developed in those areas in which, owing to their natural conditions, settlement was long delayed. Instances in which one piece of land served as common pasture for many vills were by no means rare. On the Norfolk marshes there was an extremely fertile tract of pasture known as Tilney Smeeth upon which the cattle of seven towns inter-commoned, and the modern parish map shows this area as consisting of detached portions of these villages: each village has been given a block there. At one point the partition is most minute. A space of less than 36 acres has been divided so that each village may have a rectangular portion of it. In the twelfth and thirteenth centuries rights of common were being differentiated and boundaries estab-

[1] 'Select Pleas of the Forest, 1209–1334' (ed. Turner), p. 131.

[2] Stenton, *op. cit.*, pp. 398, 542, 547.

[3] Casaubon, *ibid.*, p. 871.

[4] Stenton, p. 521. Note the distinction between Meadow and Pasture in Stenton, pp. 56 and 57.

[5] Ingulph, p. 276.

[6] At a later date cattle were brought from Scotland and Ireland and fattened in the fens.

[7] See the introduction to Miss Neilson's 'The Terrier of Fleet.'

lished and the disputes between one abbot and another "touching a marsh,"[1] together with the lawsuits connected therewith, were many and varied. They often resulted in violence and in the "making of gatherings, leagues or meetings of men"[2] whose object was to "invade the marsh and by force obtain possession of it."[3] Thus during 1332 there were many "assemblies of armed men in the parts of Holand, county Lincoln, on account of these dissensions."[4] The competing claimants used every act of violence against one another.[5] They "would many a time lame their cattle, oxen as well as horses, would daily impound their sheep and poultry, and frequently strike down, kill and destroy their swine and pigs,"[6] levelling trees down,[7] removing landmarks, and even setting fire to the dry turf.[8] At one time the Abbot of Crowland was "so impoverished by men invading the manors, granges and other places thereof against the will of the abbot and convent and keepers of the same, carrying away their goods and driving their animals and cattle to places unknown."[9] This was in 1344, and such a feature continued to the end. In 1484

> the men of Depyng assembled together to the number of three hundred men, and making an irruption into the marsh of Goggeslound, which undoubtedly belongs to the demesne of the said monastery, seized the reeds that had been collected by the men and tenants of the monastery, and threw into water or beat with strips all the people they met.[10]

In 1561 there is extant one of the Ely Bishop's letters[11] to his tenants:

> I am sorry to hear that ye are so stout so disordered and so lawless that neither the order of me and my Counsell can stay you—I understand ye fall to your old practise, please yourselves in your own devises go contrary to your own agreements and pynne your neighbours cattle. . . .

The evidence, if left at this stage, may convey a false impression of Fenland society. There is a danger of overstraining and painting too vivid a picture of the consequences that follow from the peculiarities of life within the fens. It has, for instance, been said that "fowling was the chief means of subsistence of the fen slodger,"[12] that the people of the fens "derived a precarious subsistence from fowling and fishing"[13] and that "they must have been an amphibious race largely employed in catching eels."[14] The features of such an existence have been summarized by declaring that

> The conditions of life were certainly hard in the fens. Nowhere was even the most primitive agriculture possible except on the raised spots. . . . There is evidence that a few sheep were pastured on the less damp lands, but the true

[1]Ramsey Cartulary, i, 197.
[2]Ingulph, p. 385.
[3]*Ibid.*, p. 276.
[4]Cal. Patent Rolls, Ed. III, Part II, Mem. 23.
[5]Cf. Ingulph, pp. 24–31, for a tale of conflict.
[6]Ingulph, p. 144. Cf. p. 338 also.
[7]*Ibid.*, p. 351. Cf. p. 324.
[8]Dugdale, p. 366.
[9]Cal. Patent Rolls, 18 Ed. III, Part I, Mem. 26.
[10]Ingulph, p. 493.
[11]MS. volume in Wisbech Museum.
[12]Wheeler, 'The Fens of South Lincolnshire,' p. 471.
[13]Smiles, 'The Early Engineers,' p. 16.
[14]Select Pleas of the Crown (ed. Maitland) 1891—in the court of the Bishop of Ely at Littleport.

> fenlander could be called neither an agriculturist nor a shepherd. He was a fisherman of sorts, a wild-fowler, and a gatherer of natural resources such as berries and reeds.[1]

And Macaulay[2] has dismissed the area in such terms as this:

> In that dreary region, covered by vast flights of wild-fowl, a half-savage population, known by the name of Breedlings, then led an amphibious life sometimes wading and sometimes rowing from one islet of the firm ground to another.

Such impressions were supported by statements in various itineraries (and there were many of them) of the seventeenth and eighteenth centuries written by men who with the traveller's eye noted especially what was unusual and peculiar and whose reports do not agree with those of people who had resided some time within the area and who sat down at leisure to write a reasoned account thereof. These travellers wrote with an insufficient basis of fact, and seizing what was peculiar made it characteristic. Such a product of the seventeenth century was the 'Diary' of Pepys,[3] who in 1663 travelled

> over most sad fenns, all the way observing the sad life which the people of the place do live, sometimes rowing from one spot to another and then wading.

The evidence of the manorial rolls on the one hand or of the monastic cartularies on the other lend but little support to this picture, for the mediaeval period at any rate. It is true that the original islands of the fens were never regarded as fertile, but the fact remains that agriculture formed the mainstay of the normal fen community. Thus, of the seventeen thousand acres that comprised the manor of Littleport, sixteen were nothing better than pure marsh, yet the fourteenth-century rolls of Littleport[4] definitely indicate bread and beer as the staple of existence. The high ground, small as it was, was well cultivated with cereals and pulse, with wheat and barley, oats and rye, as well as beans and peas. There is a very significant entry[5] in the Ramsey Cartulary:

> Clari et Robertus de Clervaus et
> Waltera Berneville et Radilphus de
> Osdene tenent unam piscaturam pro
> duodecim solidis.
> Et quinque acras terrae arabilis ad
> cibum piscatoris.

"For the food of the fisherman," this last sentence is very illuminating, as are the frequent references[6] to the houses, the lands and the messuages of the fishermen. Such information serves to place the special occupations of the fenland in their true perspective, for there is a danger of ascribing to these occupations, because of their very peculiarity, a fictitious importance, a danger of confusing the part with the whole, and of drawing hasty conclusions about the social life of the fens therefrom. The Domesday entries bear out the same

[1] Bygott, 'Eastern England,' p. 143.

[2] 'History' (ed. Firth), vol. iii, p. 1349.

[3] Pepys, 'Diary,' 18 September 1663. Cf. Lord Orford's 'Voyage Round the Fens, 1774.'

[4] Littleport Rolls.

[5] Ramsey Cartulary, ii, 28.

[6] *E.g. ibid.*, ii, 330, and iii, 157. *E.g.* ii, 310—a record of a fisherman "with his house and his land."

conclusion. The manors of Whittlesea and of West Walton were very normal communities within the peat and silt areas respectively. The entries relating to Whittlesea[1] are two:

(1) Manor. In Witesie the Church of Ely holds two hides. There is land to four ploughs and a half. One hide in the demesne, and there is one plough and a half. There are eight villanes and four cottagers with three ploughs. There are three bondmen; meadow for one plough; pasture for the cattle of the village; for a stream of water two shillings. It was worth four pounds. T.R.E. 100/–. This manor lies, and always laid, in the demesne farm of the Church of Ely.

(2) The Abbot of Thorney holds 4 hides in Witesie. There is land to 6 ploughs. Two hides are in demesne and therein two ploughs; and sixteen villanes of 8 acres each, and six cottagers with 4 ploughs. There is one bondman; meadow for six ploughs; pasture of the cattle of the village; for a stream of water 4/– and besides 20/– for fish. For all dues it is worth 6 pounds; when received 20/. T.R.E. seven pounds. The manor laid and lies in the demesne of the Church of Thorney, but the Abbot of Ely has the soke.

Waltuna[2] has four entries which taken together give a fair picture of its life:

(1) Waltuna was held by Toche a freeman T.R.E. Now St Peter holds (it as) 4 ploughlands; then as now 9 villeins. Then 63 bordars, now 67. Then 14 serfs now 8, and 100 acres of meadow. Then 6 ploughs on the demesne; afterwards none, now 5; then as now 6 ploughs belonging to the men. Then 1½ saltpans, now 6. Then 14 rounceys now 8. Then 36 mares now none. Then 24 beasts now 23. Then 100 swine, now 114. Then 700 sheep, now 800. To this manor belong (jacent) 6 sokemen, 1 ploughland and 10 acres (of land), and 30 acres of meadow; then as now 17 bordars, and 3½ ploughs and 7 saltpans. The whole is worth 17 pounds and 10 shillings. The whole is 4 leagues in length and 2 furlongs in breadth, whosoever may hold there, and pays 2/– in a geld of 20/–. This is of the fee of F(r)ederic.

(2) Waltuna was held by St Etheldreda T.R.E. for 4 ploughlands. Then as now (there was) 20 villeins (and) 40 bordars. Then 17 serfs, now 13; 100 acres of meadow, 1 fishery. Then as now 5 ploughs on the demesne and 3 ploughs belonging to the men. The 22 saltpans, 24. Then as now 6 rounceys. Then 18 beasts, now 16. Then 22 swine, now 23. Then as now 1300 sheep. To this manor belong (hic jacent) 47 acres of land in Esingatuna (Islington) which now as then are held by 2 villeins. And 7 sokemen with one ploughland, and 11 bordars and 3 serfs. Then as now 2 ploughs. Now as then it is worth 15 pounds.

(3) In Waltuna Bunde a freemen held 1 ploughland, T.R.E. Now Odar holds it. And (there are) 4 villeins and 8 bordars and 4 acres of meadow. Then as now (there was) 1 plough on the demesne, and 1 plough belonging to the men, and 1 freemen with 8 acres of land, and it is worth 20 shillings.

(4) In Waltuna 3 freemen (had) 91 acres which Bordin holds. Then as now (there were) 9 bordars and 12 acres of meadow. Then (there were) 1½ ploughs, now 1. It is worth 9 shillings and 4 pence. And in this (his predecessor had nothing) but the commendation. Half a church (holds) 15 acres, and is worth 2 shillings.

The labours of successive generations of monks and the example they supplied were not without reward. Grants of arable land[3] grow more and more numerous. Nor was this effort limited to the necessities of existence. In

[1] D.B. Cambs. (ed. Evelyn-White), 33, 47.
[2] Victoria County History for Norfolk, vol. 2, Domesday section.
[3] *E.g.* in Stenton: Danelaw Charters; Ingulph.

Ramsey were to be found "vinea et pomeria,"[1] likewise in Ely[2] and in Littleport too.[3]

Yet this cultivation, important as it was, was not carried on without a certain amount of struggle. "In the winter if there happened to be any floods,"[4] the embankments which had been constructed broke down before the face of the swollen waters.[5] "For every year," says Ingulph, "as the waters increased to overflowing, the channel was unable to contain the increasing waters within the banks, and, consequently, by repeatedly washing away the soil, the waves overflowed the said embankment."[6] Nor, as often as not,

> did the embankments offer any effectual resistance, but on the contrary though materials had been brought from other quarters for the purpose of strengthening them, they proved of very little service for that purpose; and however diligently the work might have been attended to in the day time, as the waters swelled and rose, the spot under repair was completely laid bare during the night.[7]

And at such times both arable and pasture-land were submerged and the sea "drowned many cattle and spoiled a great quantity of corn."[8] The accounts of these floods, preserved in the Patent Rolls,[9] are both numerous and vivid in the extreme. In the century from 1250 to 1350 the Marshland of Norfolk was flooded some twelve times. On one of these occasions, in 1337, the people of Tilney grievously reported[10] that

> the same bank was so broken, by the raging of the sea, in no less than five places, that the town of Tilney was overflowed with the sea-water, and the lands, meadows and pastures belonging thereto, continually drowned for the space of seven days, by which means their winter corn, then sowed upon the ground, was destroyed, as also much of the corn and hay in their barns, with an hundred muttons and sixty ewes to the damage of cccl unto the said town.

Not infrequently the Marshmen fought a losing battle against the waters. The 'Historia Eliensis'[11] has an account of a

> little island called Elmeneie, which became by the swelling of those waters almost drowned. Upon a great complaint, therefore made by the said monks unto Alkeric Picot, he gave them four acres and a half of ground in the Isle of Denney, which lay without the reach of the fen; to the end that they might translate their home thither, and make orchards and gardens there for their use.

The inhabitants were very much alive to the need of cleansing or repairing[12] the dykes, for it was upon their strength that the extent, to say nothing of the existence, of the arable ground depended. But it often happened that measures taken to drain one spot merely had the effect of flooding another man's lands,

[1] Ramsey Cartulary, iii, 233.
[2] William of Malmesbury, 'De Gestis Pontificum Anglorum' (Rolls Series), p. 326.
[3] Littleport Rolls.
[4] Ingulph, p. 493.
[5] *Ibid.*, p. 400.
[6] *Ibid.*, p. 350.
[7] *Ibid.*, p. 444.
[8] Cal. Patent Rolls, 10 Ed. III.
[9] Dugdale's Collection.
[10] Cal. Patent Rolls, ii, Ed. II, n. 110.
[11] Dugdale, *ibid.*, p. 356.
[12] *E.g.* Ramsey Cartulary, 1, 463, 476, etc., etc.; 2, 17, 23, 28, etc.

or perhaps interfered with another's fisheries, or another's mills, or made a channel unsuitable for navigation. Thus in the early part of the fourteenth century Walter de Langetone built a "stop" in the Welle River "whereby merchants and others were hindered[1] from passing with their ships, boats and other vessels" and whereby also "lands, meadows, pastures and marshes . . . were overflowed and drowned." For all these things he was summoned. The disputes caused by such incidents were very numerous. They occurred between every abbey and each of its neighbours; notice of them recurs again and again in the pages of the monastic annals, and they frequently led to violence. In 1329 the Abbot of Crowland complained[2] how

> Walter prior of Spaldyng . . . and others, cut in pieces the beams placed to strengthen the dykes constructed to prevent the abbey from being submerged and washed away, overthrew the sand-dikes, filled up the trenches so that the land in cultivation is more flooded to the great injury of the abbey. . . .

A few years later, on 8 June 1342, complaint was made[3] by Thomas Wake of Lydell:

> that Henry Abbot of Croyland . . . and others broke a dyke raised in his marsh at Depyng county Lincoln, to protect the same against the flow of fresh water there, whereby the marsh was inundated, his turves dug therein were destroyed, and he lost his profit of the marsh for a great while, fished in his free fishery there and took and carried away fish.

When the necessity arose, the Crown frequently granted a Commission to inquire into and remedy the evils of flooding, but no attempt was made to view the matter in a broad way, and it was not until 1600 that a "General Drainage Act" was passed "for the recovering of many hundred thousands of acres of marshes." During the early years of the seventeenth century many schemes were proposed, and the middle of the century saw the beginnings of a comprehensive effort to convert the great level into "winter grounds."

[1] Cal. Patent Rolls, 17 Ed. II, Pt. I, Mem. 6 in dorso.
[2] *Ibid.*, 3 Ed. III, Pt. I, Mem. 3d.
[3] *Ibid.*, 16 Ed. III, Pt. II, Mem. 34d.

THE DISCOVERER OF THE KAIETEUR FALL

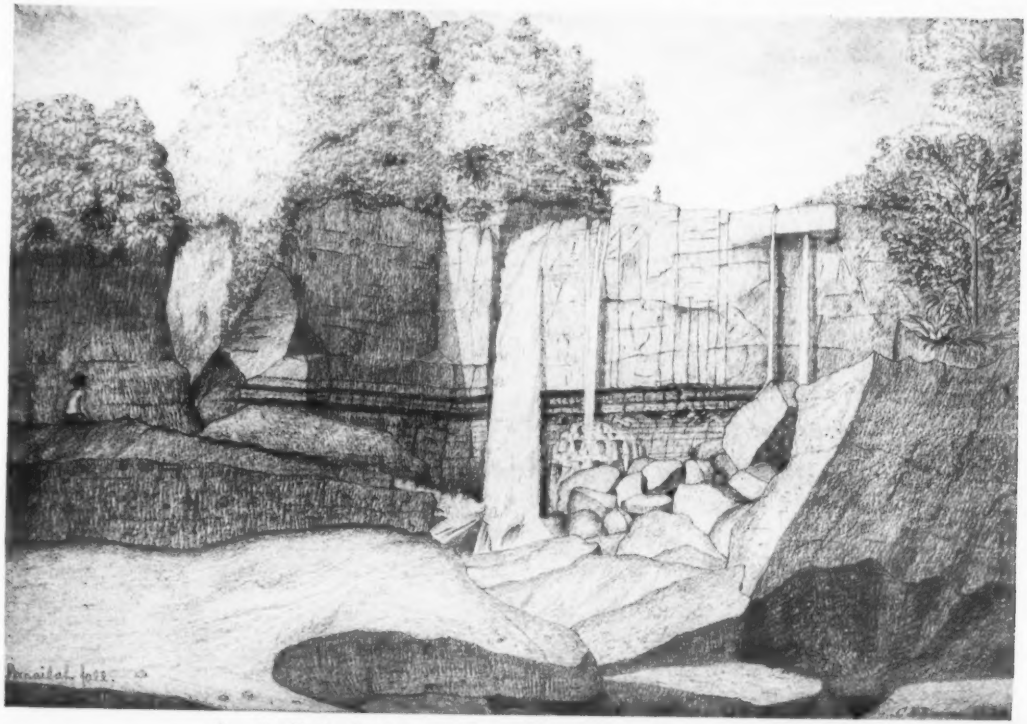
[*The Society is indebted to Mr. C. Barrington Brown, son of the discoverer, for the following note and for the loan of early drawings and photographs of the Kaieteur and other falls in British Guiana, which have been shown lately in the Exhibition Room. A fine photograph of the Kaieteur Fall, taken by the late Sir Everard im Thurn at a time of drought in* 1878, *was reproduced in the Geographical Journal for December* 1916, *vol.* 48, *facing page* 458.—ED. *G.J.*]

WITH the increasing interest in our Colonial possessions in the middle of the last century it was considered desirable to determine the mineral resources and investigate more thoroughly the river highways of British Guiana. In 1867 James G. Sawkins and Charles Barrington Brown were appointed by the Colonial Office to conduct a geological survey and began their work at the end of that year. In June 1870 Sawkins retired and Brown continued the work single handed. The latter was six years in the colony, and during that time travelled 2130 miles on foot and more than 8000 miles on its rivers. He explored nearly every river of consequence and made a geological reconnaissance of a great part of the colony; but the most memorable feature of his work is undoubtedly his discovery of the Kaieteur Fall.

At the beginning of 1870 Brown set out to examine the geology of the central region: that tract of country lying between the Essequibo, Rupununi, Ireng, and Mazaruni rivers. His original intention was to leave the Essequibo and ascend the Potaro, but the Tumatamari cataract proved such a serious obstacle that to save time he decided to work his way round later on and to descend this river from its source. After exploring the Siparuni and Burro-burro rivers and their tributaries, he started on foot from Surama, a village on the Upper Burro-burro, on April 4. The party consisted of thirteen of his own men and three Indians. Travelling westwards they reached the Ireng valley and, turning north, passed along the western slopes to the Tawailing Mountains, where they followed a tributary of the Ireng; passing over the watershed they reached a tributary of the Potaro. At Taepong, a Macusi village near the entry of this tributary into the Potaro, Brown was told that it would take many days to reach the Essequibo and that a very large fall "as high as trees" would cause much delay. Although the party was now reduced to only eight, some having been sent back earlier, Brown and his men had been living for some days on nothing but cassava bread, since game was scarce and all salt provisions had been consumed. To return would have meant certain starvation, and the only course was to push on. Fortunately woodskin canoes were found lower down on the Potaro, and late in the evening of April 23 the party encamped a mile above the fall, the roar of which was distinctly heard. The next day, proceeding on foot, Brown reached the top of the fall. The morning was cloudy and a heavy mist rose over the edge and fell as a light rain; at first he thought it actually was a rain squall, but soon saw that it was produced by the fall itself.

The fall, one of the great natural wonders of the world, has since frequently been described, but the words of the discoverer are worth quotation ('Canoe and Camp Life in British Guiana,' London 1876, pp. 203–204): ". . . Walking to the edge of the precipice, down which the water was precipitated, I gazed

Kaieteur Fall: sketch made by Barrington Brown at the time of his discovery, 24 April 1870



Amaila Fall, Curiebrong River: sketch by Barrington Brown

with wonder and delight at the singular and magnificent sight that lay before me. Not being prepared for anything so grand and startling I could not at first believe my eyes, but felt it was all a dream. There, however, was the dark, silent flow of water down which we had travelled, passing slowly but surely to the brink of a great precipice and breaking into ripples as it approached its doom. Then curving over the edge in a smooth mass of a brownish tinge, changing into snow-white fleecy foam, it was precipitated downwards into a black seething cauldron hundreds of feet below. Of how many hundreds I could not with certainty make out; but, judging from the appearance of the river below the basin, I thought it must be near upon 900 feet. I was prepared to meet with great falls on our way down, knowing from our altitude by aneroid that we were some 1200 feet above the sea on the Upper Potaro, and that the mouth of the river was at a level of only 65 feet, but nothing of so grand and extraordinary a nature as this even entered my mind for a moment."

During a brief stay at the top of the fall, Brown made a pencil-sketch (Plate 1). He then descended the steep mountain side on the north and arrived at the foot of the last cataract between that spot and the basin of the fall. He estimated by aneroid the height of the fall as 900 feet. Continuing the journey down the Potaro he reached the Tumatamari cataract on April 28 and Georgetown on May 6.

Upon Brown's report of this discovery of such a remarkable natural feature, the Governor of the Colony, Mr. John Scott, directed him to return to make a thorough examination. Accompanied by Sir George Young, Mr. Mitchell, and Mr. King, he left Georgetown on June 28 and arrived within sight of the fall on July 15, having with great difficulty ascended the Potaro river with its numerous cataracts round all of which the boats had to be hauled on land. On the 17th the party took simultaneous readings at the top and base of the fall. Young and Mitchell then returned to Georgetown, leaving Brown and King to continue observations as to the width and velocity of the river. The fall is in long. 59° 10′ W. and lat. 5° 08′ N. It is produced by the Potaro river flowing over a sandstone and conglomerate tableland into a deep valley. The water falls as a perpendicular column, 741 feet high, into a basin from which it sweeps over a sloping cataract 81 feet high and between great blocks of rock to the open river. The head of the fall is 1130 feet above sea-level. The width of the river at a point 200 yards above the edge of the fall is 134 yards, and at the edge itself 123 yards. Behind the curtain of water is an immense cave, the home of flocks of swallows. A very hard conglomerate 20 feet thick overlying reddish-grey sandstone of less durability is the cause of this great perpendicular fall. The journey to it from Georgetown can now be made in comfort in six days by the same route up the Essequibo and Potaro rivers.

During an expedition in the central region in the latter part of 1870 an ascent of the Curiebrong, a tributary of the Potaro, was made with the object of finding a fall which the Indians called Amaila and assured Brown was as high as Kaieteur. It was a great disappointment to him to find that the perpendicular part of the fall was merely 100 feet, though in a distance of 2 miles the water falls over sloping cataracts through a height of 1280 feet. A pencil-sketch made by Brown at the time is here reproduced (Plate 2). At the head of the Ireng river, just above the entry of the tributary Suquabi, there is a

Amaila Fall, Curiebrong River: sketch by Barrington Brown

fine fall in beautiful scenery, called by Brown by the Indian name Orindouie. He appears to be the first to have seen it. The width of the river is 56 yards and the water flows over three steps on the western half, a height of 213 feet. The eastern half is more regular, the vertical column of water being 162 feet. On 5 November 1907 Dr. Carl Bovallius (who died four days later) announced in the *Daily Telegraph* and other newspapers of November 26 the discovery of a fall, for which he proposed the name of Chamberlain Falls, "rivalling Niagara." They appear to be identical with the Orindouie. This fall was visited by C. W. Anderson, Government Surveyor, in 1906, who calls the fall Kulutuik-Wena, though noting that the fall is called Orindouie on the 1875 map of the colony which was prepared by Brown and Sawkins.

In exploring the Corentyne River, the boundary of Dutch and British Guianas, it was found that just above the King Frederick William cataract the river divides in two: one branch, the more easterly, rising about lat. 2° N. and long. 56½° W., and flowing with a north-north-west course, changes to due west some miles above the junction; while the other branch, rising about lat. 2° 10′ N. and long. 58° W., flows northwards. This latter tributary, named by Brown the New River, was hitherto unknown, and after exploring both branches to their source, he decided that the New River was the true Corentyne and not the more easterly arm, which has less than half the width at the junction.

Beyond his official reports to the Governor of the Colony and to the Colonial Office, and a communication to the Royal Geographical Society, published in the *Proceedings* of 12 July 1871, vol. 15, pp. 122–131, no mention of his discovery of the Kaieteur Fall has been made by Barrington Brown in his writings other than the brief account of less than two pages quoted above from his 'Canoe and Camp Life in British Guiana,' and few visitors to the Great Fall know the name of its discoverer.

THE RECENT ASSAULTS ON KANGCHENJUNGA

IM KAMPF UM DEN HIMALAJA. By PAUL BAUER. *Munich: Knorr und Hirth* 1931. $9\frac{1}{4} \times 7$ *inches; 174 pages; illustrations, panoramas, and maps. M.9.40*

THE KANGCHENJUNGA ADVENTURE. By F. S. SMYTHE. *London: Victor Gollancz* 1930. $9\frac{1}{2} \times 6$ *inches; 464 pages; illustrations and sketch-maps.* 16*s*

HIMALAYA: UNSERE EXPEDITION, 1930. By G. O. DYHRENFURTH. *Berlin: Scherl* 1931. 9×6 *inches; 380 pages; illustrations, panorama, diagram, and map. M.16*

KANGCHENJUNGA, "the five treasuries of the great snow," lies on the frontier of Sikkim and Nepal, and is, as far as can be ascertained at present, the third highest mountain of our Earth. Secure behind its almost inaccessible outer ramparts—the great range carrying Kabru and extending southwards to the Singalila ridge, the eastern range, carrying the icy summits of Simvu and Siniolchu, and the western ridge dividing at Kangbachen to the crests of Jannu and Ramthang—it has remained an object of worship to the inhabitants of Sikkim for centuries and of admiration to the British ever since the occupation of Darjeeling as a hill station nearly a hundred years ago.

This is not the place to describe in detail the history of the early exploration of the approaches to Kangchenjunga. Such an exploration must be a gradual process, and many have had a hand in it. Hooker, Harman, Tanner, Claude White, all had a share in paving the way for Mr. Douglas Freshfield's great circuit described in 'Round Kangchenjunga,' and each in turn benefited by the work of his predecessor. At the beginning of the present century enough was known of the approaches to begin a reconnaissance of the mountain itself.[1] Mr. Freshfield showed that the two highest summits, 28,146 feet and 27,803 feet, rise from a stupendous range running approximately north and south. West of the northern summit and east of the southern, great ice-clad buttresses support the massif and enclose the ice-basins of the four main glaciers of the group. The Kangchenjunga glacier fills the north-western quadrant and drains the whole western side of the northern range as far north as the Jonsong La; the Yalung glacier fills the south-western quadrant and drains the western face of the southern range almost to the Kang La. Both these glaciers are wholly in Nepal. The Talung glacier clothes the south-eastern face and quadrant; and the Zemu, with its now well-known tributaries, the north-eastern. These four glaciers form the only approaches to the mountain; and from these approaches, on all sides, Kangchenjunga is defended by precipitous walls 6000 feet high before the gentler gradients above 23,000 feet can be attained.

If we analyse these four quadrants we find that the south-eastern and south-western are the nearest to Darjeeling. Compared with the other two they are however much more exposed to the full impact of monsoon storms, and certainly from mid-June to mid-October no periods of settled weather can be expected. The faces of the mountain on these southern sides are ice-armoured and, as Raeburn said of the Talung Saddle, "vicious in the extreme, defended everywhere by overhanging masses of ice." It is nothing short of madness to attempt to climb either of these faces, especially during the monsoon period. The two northern quadrants lie protected to a large extent from the worst of the monsoon storms, and Mr. Freshfield showed that there was no great difficulty in reaching

[1] For a brief history of exploration in the Kangchenjunga region see *Himalayan Journal*, ii, 1930.

the head of the Zemu glacier. There however he experienced bad weather and was unable to carry out a detailed reconnaissance. He approached the north-western quadrant from the north and is frequently quoted as having expressed his opinion that the only direct route to the summit was from this direction. What he actually said was that the great snow-terrace lying at about 27,000 feet, which is continuous to the north ridge, afforded in his opinion the only practicable route. He made no recommendation that this terrace should be attacked from the north-east or from the north-west.

The first twenty-five years of the century added greatly to our knowledge of the approaches to the central massif. Messrs. Raeburn and Crawford proved the impracticability of the Talung Saddle, and indeed the inaccessibility of the whole ridge separating the south-eastern and south-western quadrants, as far south as the Kang La. The investigations of these two and of Messrs. Tombazi and Boustead and Lieut.-Colonel Tobin left no doubt that the southern quadrants were raked by avalanches and that it would be most unwise to force a line of communication to the Zemu glacier by way of the Para Chu, the Guicha La, the Talung, and the Tongshyong glaciers and the Zemu Gap, though Dr. Kellas had reached the latter from the north without much difficulty in 1910. The explorations of Dr. Kellas in 1907, 1909, and 1910 also showed that a direct passage from the north-eastern quadrant to the north-western, by way of the Nepal Gap, was impracticable for laden porters. The upper regions of the four quadrants were thus shown to be isolated from each other. The very serious objections to attempting to climb the mountain from the north-west are, firstly, that there is difficulty in obtaining permission to approach it through Nepal, and secondly, that an attack from that side means a very long line of communication over several high passes, including the Kang La, which is liable to be blocked by bad weather. From all these considerations mountaineers had, by 1929, come to the conclusion that the north-eastern quadrant offered the most likely line of successful attack, with a comparatively easy line of communication by way of the Tista valley and Lachen.

Herr Bauer and his team of young Bavarians arrived in India in July 1929. They were fully equipped for strenuous climbing in the high Eastern Himalaya. They had studied all the available literature on the subject, learnt the lessons of the Mount Everest expeditions, consulted authorities on high Himalayan mountaineering; they had been trained in a difficult school and were absolutely fit. They sought advice and took the best they could get; and at the end they generously acknowledged it. Some of the most experienced and trustworthy native porters of the Mount Everest expeditions had been collected by the Himalayan Club for them, and after a halt of only three days they pushed on by Freshfield's route by the Tista valley and the Poki Chu to the Zemu glacier.

The first of the books under notice is an extremely modest account of this first Bavarian expedition, which has been described subsequently by an experienced Alpine Club member of the Mount Everest Expeditions as "a feat without parallel, perhaps, in all the annals of mountaineering." It is not too long, especially when dealing with preliminaries and ground well known to mountaineers; yet it is sufficiently detailed throughout to enable the reader, whether experienced or not, to realize the tremendous difficulties encountered and overcome. It is so well illustrated that it may be used usefully to supplement the briefer but no less thrilling accounts in English written by Herr Bauer for the *Alpine Journal* and the *Himalayan Journal*.[1] Herr Bauer sticks to essentials; there is no attempt at journalism; the men who played their part on the lines of com-

[1] *Alpine Journal*, xlii, 1930, p. 185; *Himalayan Journal*, ii, 1930, p. 13.

munication and in the lower camps receive as much praise as those who formed the storming party. A fine spirit of camaraderie permeates the book as no doubt it permeated the adventure. The actual account of the climb, which occupies some sixty pages out of a hundred and seventy-four, is of intense interest. It tells how, after a month's hard work spent in laying a forward base, Camp VI was pitched near the head of the glacier, where, after several reconnaissances the North-East Spur, a subsidiary buttress of the great North Ridge, projecting eastwards, was selected for the assault.

Three attempts to reach the crest of the Spur were frustrated by overhanging masses of ice. On September 6 the crest was conquered. A violent blizzard caused the gains to be relinquished and the whole route was obliterated. The party was driven back to Camp VI. "We were now ready to start the real assault," writes Bauer, and on the 16th the crest of the Spur was reached for the second time, after many days of hard step-cutting. The route now turned westwards along the North-East Spur and a track fit for porters had to be cut to circumvent the series of great ice-pinnacles which crowned the spur. Great masses of ice had to be cut away, tunnels had to be pierced, and caves dug to serve the duties of Camps VIII, IX, and X, the last of which was established on October 2 at 23,030 feet. It had taken a month to attain Camp X from Camp VI at 16,860 feet.

Kangchenjunga was stirred at last. Her icy solitudes had been violated by men of science, determination, and skill. On the night of October 3 came a fierce wind, a bitter blizzard, and intense cold. The storm lasted for four days. To economize food four of the party had started down. A second party began the descent, while one forlorn attempt was made to go higher. On the 7th, when all three parties were isolated on the mountain, cut off from each other and the base, 6½ feet of snow fell. It is almost impossible to conceive the difficulties and dangers of the descent as described by the leader in his book. The storm endured was one of the worst experienced in Sikkim for years.[1]

The three parties descended, each unaware of the fate of the rest. In one account of the descent Bauer writes: "The descent appeared humanly impossible, yet the attempt had to be made. Roped at the fullest possible distance we fought our way down, leaving behind us a furrow a man's height in depth. . . . Our unfortunate porters, laden each with some 80 lbs., sank so deep that we, with our 40 lbs., had often to pass them and jerk them loose from below. The steeper slopes mostly peeled off as the leader, tightly held from the rear, stepped on to them. The great and most dangerous slope, thank Heaven, had already avalanched. . . . Another slope, however, parted with Allwein and the two porters on it, but with a final desperate effort I was just able to hold them. For ten minutes or more we lay motionless and exhausted before we could resume the fight. On our arrival at Camp IX we had to dig for half an hour before we could clear the ice-cave's entrance, buried in seven feet of snow."

Beyond Camp IX the descent became more difficult, but after jettisoning half the loads by casting them to the Twins Glacier, 5000 feet below, the last party reached Camp VII and comparative safety. The party of Beigel and Aufschnaiter probably had the hardest time. They were caught between Camps IX and VII, the most dangerous part of the descent, during the worst weather experienced on the expedition. Alternately leading, each was swept off his feet by avalanches. Once, when traversing slightly below the crest, the leader slipped and was held only by the second man leaping into space on the reverse slope. This manoeuvre

[1]The writer of this note was in Sikkim at the time. Much destruction to roads was caused by this storm, and travel became impossible.

led to the loss of loads and bivouac material, and the party had to spend the night on the ridge with no provisions or shelter of any kind. The whole party was eventually reunited and reached the Zemu glacier, whence the return was made by the Tista to Darjeeling.

Thus ended Bauer's first attempt, a brilliant effort, defeated by the break-up of the weather at the critical point. It is safe to say that the exhibition of mountain craft can rarely, if ever, have been equalled in the history of mountaineering.

In 1930 took place the next attack, this time by an international expedition of ten members, of German, Austrian, Swiss, and British nationality. The second and third books under notice are the accounts by the leader, Professor Dyhrenfurth, and Mr. Smythe. Briefer accounts by these two members of the expedition have also appeared in the *Himalayan Journal* (Professor Dyhrenfurth) and in the *Alpine Journal* (Mr. Smythe).[1] Plans were based on the experiences of previous expeditions and the assistance of the Himalayan Club was invoked, albeit rather late. Preparations were made to attack the mountain again from the north-east, but at Darjeeling permission was received to pass through Nepal, and at the eleventh hour it was decided to change the programme. This unfortunate change was the cause of much subsequent dislocation on the long and difficult line of communication by the Kang La and other high passes to the north-west quadrant. In order to take full advantage of the pre-monsoon period an early start was made, but having planned the transport arrangements suitable for the Tista valley route it was not possible to equip completely the many additional porters required for a longer route involving four passes between 13,600 and 15,000 feet, and one over 16,400 feet, all under snow and none practicable for pack animals. The transport officers were called upon to face an impossible task and the communications became disorganized.

By the end of April however the difficulties had been overcome, though not perhaps without some misunderstandings, and plans were made for the assault. From a base camp a little to the west of Pangperma, at a height of 16,570 feet, opposite the tremendous north-west face of Kangchenjunga, Camp I was to be pitched at the upper end of the flat portion of the Kangchenjunga glacier and Camp II on the névé under the north col. From here a camp on the great ice-wall near the north end was to be established on the first terrace where a staircase, requiring several days' hard work, would be cut to the north ridge.

It is easy to be wise after the event; but the lessons of previous high attempts do not seem to have been fully appreciated. There is probably no greater danger in the Himalaya than working on ice-walls below the high ice terraces. The plasticity of the ice above is deceptive, and without warning thousands of tons may suddenly be let loose in the form of a terrible ice-avalanche. There is no hope of escape for any one caught below; the huge ice-blocks hammer and batter and eventually crush him to death. For this reason ridges are to be preferred to faces. On May 9 the ice-wall was almost conquered when the ice avalanched. A great mass of the terrace above broke off and the huge blocks came crashing down. Smythe, a spectator of the disaster from below, describes it vividly in 'The Kangchenjunga Adventure.' Had it occurred five minutes before or five minutes later the whole party must have been obliterated. As it was, Chettan, the most gallant of the Mount Everest "Tigers," was caught and crushed to death, and further climbing on this face had to be abandoned, though some brilliant climbing was accomplished on the great west ridge and some outstanding exploits carried out farther north. A good deal of exploration, supplementary to that of Mr. Freshfield, and survey, supplementary to that of Professor Garwood, was accomplished.

[1] *Himalayan Journal*, iii, 1931, p. 77; *Alpine Journal*, xlii, 1930, p. 202.

The accounts of these lesser explorations and the beautiful map of M. Marcel Kurz are the most valuable parts of Professor Dyhrenfurth's book. A bold experiment had been made to climb one of the most difficult of the Himalayan giants with an international team of leading mountaineers; it deserved a greater measure of success than it attained. The change of plan at the last moment, the consequent and inevitable dislocation of the communications, the difficulties and disappointments of attempting the impossible, did not make for complete harmony, such as is essential for success. It is not surprising, in view of the fact that Mr. Smythe's book was published first, that the British member of the party does not seem to have collaborated in the production of this book.

In some ways Mr. Smythe's book is brilliantly written, but in a rather journalistic style. The preliminary chapters are drawn out, and not till p. 200 or thereabouts is the Base Camp reached. There is also perhaps a tendency to claim omniscience and infallibility of judgment on the part of the author, while pointing out the errors of other members of the expedition. One grows a little tired of criticisms on equipment, especially when repeated.

We understand that M. Kurz was equipped with a Zeiss phototheodolite and intended to plot a stereo-photogrammetric survey. M. Kurz's map is naturally an improvement on the one drawn by Professor Garwood on Mr. Freshfield's more hurried expedition of 1899, which has rightly held first place for so long. M. Kurz has borrowed much from this and from the Survey of India map; he has corrected and added a lot of information in the north-west quadrant, but the appearance of the contours does not suggest that they were plotted stereographically: rather that they are sketched from spot heights. Stereographic survey can be of the greatest value for mountain surveys. It will be interesting to see the results of Herr Karl Wien's survey by this method carried out during the Bavarian expedition of 1931 and now being plotted under the direction of Herr Finsterwalder.

The year 1931 witnessed a further attack on Kangchenjunga by Bauer. Once more a fine team of young Bavarian climbers was collected: six of the 1929 party and four new men, all with considerable climbing experience to their credit. The full account will be looked forward to with the greatest interest. The following notes are from the preliminary accounts published in the *Alpine Journal* and the *Himalayan Journal*;[1] by the kindness of Signor Sella we are able to illustrate the route of this and of their previous attempt by two photographs which he took when he was with Mr. Freshfield in 1899, on which he has marked the approximate positions of Bauer's camps.

The North-East Spur was again selected for assault, and the same route was taken as in 1929. The main attack commenced on July 14, when stones and avalanches were still extraordinarily active. Abnormally warm weather rendered the snow conditions more dangerous than in 1929, and an observation post was formed to ascertain the safest time of day on which the route to the site of the old Camp VII could be traversed. Then all went well till the route to Camp VIII had been prepared, though an intermediate camp (Ridge Camp) had to be established between Camps VII and VIII. It was on August 9, when moving up to occupy Camp VIII, that a serious accident occurred. Two Bavarians had attained the terrace of Camp VIII; Herr Schaller followed after carefully cleaning the steps. Next to him came an experienced porter, Pasang. A third porter remained behind to pay out the rope. Suddenly Pasang shot down the steep gully, followed immediately by Schaller. The rope broke and both men were killed.

[1] *Alpine Journal*, xliv, 1932, p. 13; *Himalayan Journal*, iv, 1932, p. 116.

Fifteen days after the accident Camp VIII was definitely established. The weather had become exceptionally warm and much extra care had to be exercised. The porters were, rather naturally, badly shaken by the tragedy, and with three notable exceptions could no longer be relied on beyond Camp VII. The extra carrying that had to be done by the climbers delayed them and must have worn them out. The cave at Camp X, cut higher than the Camp X of the 1929 expedition, at 23,620 feet, was occupied on September 10, the cave at Camp XI at 25,100 feet on the 16th, and on the following day, after plodding over vast slopes of deep powder snow, the highest crest of the North-East Spur, at about 26,200 feet, was reached. Beyond this point the snow was unfavourable and the party returned to Camp XI.

On the 18th three members of the party set out for a further reconnaissance and to excavate Camp XII, but found the slope forming the sole approach to the North Ridge totally unassailable owing to the avalanche condition of the snow. There is little doubt that, however hard it was to make the decision to abandon the climb, the right decision was made. Bauer sums up this decision in these words:

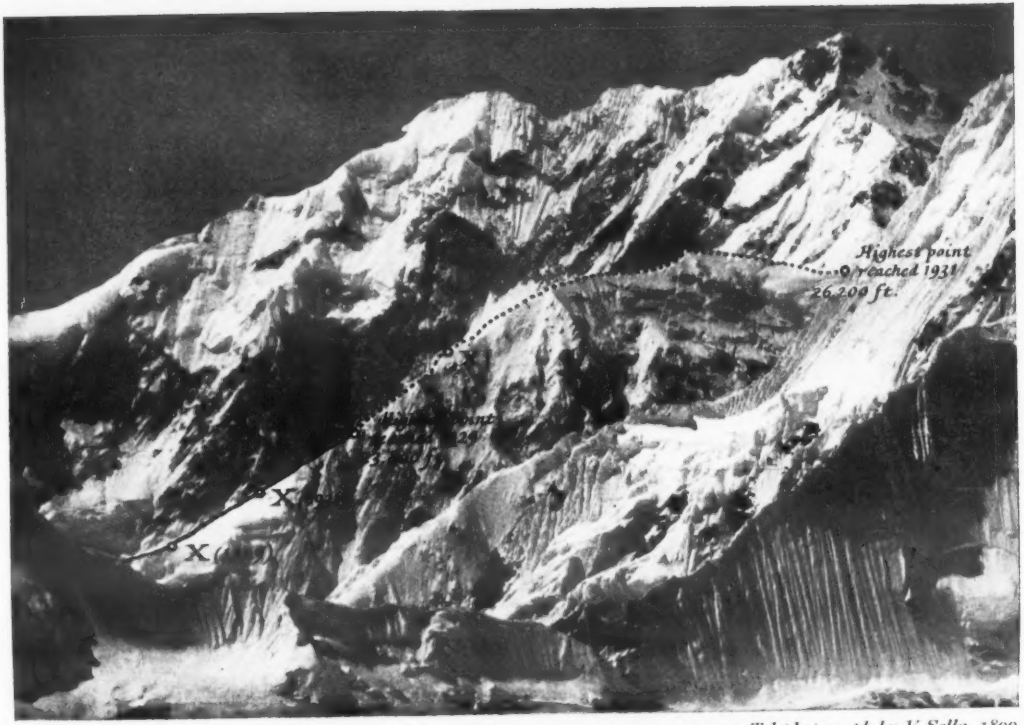
"No doubt the unfavourable state of the snow was only temporary; but unfortunately at such a time there was no prospect of it improving, for every day it snowed for several hours. There was also now the constant menace of a great snow-fall such as had two years before forced upon the expedition a most hazardous retreat demanding the utmost exertions. The issue of a second retreat over deeply snowed-up slopes and ridges from those high altitudes could not be foreseen. Although our leading party had had six weeks to get fully acclimatized to the high altitude and our speed of ascent up to 8000 metres had not sunk below half that customary in our native mountains, yet it must be remembered that we had carried our heavy rucksacks for forty days almost without a single day of rest and had carried out some very trying ice-work which had set a great strain on our reserves of strength. We might have ventured a final assault in which all was staked on a single card, but even so we must have waited; and a long wait at those heights, if it is possible at all, demands fresh forces. In consequence of these considerations, we felt that there was no option but to renounce final success. An immediate attack on the slope would have been senseless and inexcusable."

The Editor of the *Alpine Journal*, in a brief note on Paul Bauer's account of his last expedition, writes: "To comment at length on the great 1931 struggle would be mere presumption. It will be sufficient to state that for skill, endurance, cold-blooded courage and especially for *judgment*, the expedition will stand as the classical model for all time." This comment will be endorsed by all who know the Himalaya.

Thus ended the 1931 attempt to conquer Kangchenjunga. Each of these three attempts, the accounts of which are here summarized, have increased our knowledge of the topography of the mountain, of its difficulties, and of the organization necessary to success. Before further attacks take place the lessons of these three expeditions must be absorbed. It would seem certain that Bauer's route alone is practicable; but it will indeed be a wonderful party that succeeds where he has failed. It would also seem that only a party of men in the fittest possible condition at the start can hope to reach the summit; and this party must be homogeneous, as was Bauer's party. On the first expedition Bauer himself was the oldest member at thirty-two; the average age was twenty-six. The utmost forethought must be exercised before attempting any of the Himalayan giants; personnel must be selected with the utmost care; plans once made should not be altered at the last minute when it is too late to adapt equipment to fresh

Telephotograph by V. Sella, 1899

The North-East Spur of Kangchenjunga from the Lower Zemu Glacier, showing the route of Bauer's expeditions, 1929 and 1931



Telephotograph by V. Sella, 1899

The North-East Spur from Gangtse on the Lhonak Chu

Telephotograph by V. Sella, 1899

The North-East Spur from Gangtse on the Lhonak Chu

needs; and single-mindedness of purpose must pervade every member of the expedition.

One is tempted to consider again the question of the use of oxygen. Would it have been of any use? After the last Mount Everest expedition the conclusion was reached that for a mountain of considerable altitude a light form of oxygen apparatus might be taken with advantage, but that it should be considered solely as an emergency measure. For success acclimatization must be attained without oxygen. The Bavarians acclimatized, but in the two accounts of the attempt referred to, Bauer has said little of his collapse at Camp X from severe heart strain. He attempted to descend alone, and had to spend a terrible night in the cave at Camp IX without sufficient covering. An emergency supply of oxygen here, even in very small quantity, might have helped him down to Camp VIII and comparatively comfortable quarters.

Little has been said here of the explorations carried out by these expeditions otherwise than on Kangchenjunga. Mention has been made of the climbing accomplished by the international expedition of 1930 north of the mountain, of the fine map by Marcel Kurz which appears in Dyhrenfurth's book, and of Karl Wien's photogrammetric survey in 1931. The whole of the north-west and north-east quadrants of Kangchenjunga and the region of the Upper Lhonak have now been surveyed in some detail. At the end of the expedition some fine pioneering was carried out by two members of Bauer's team. Allwein and Pircher, with three porters, crossed the Simvu Saddle on October 1 for the first time—it had been reached from the north by Dr. Kellas in 1910—and descended in a south-easterly direction down the unknown Passanram valley, which had never before been trodden by any European. This indescribably savage valley, only 25 kilometres long as the crow flies, took the party seven days to traverse. They eventually reached the Talung valley, where the villages of Pangong and Sanven are marked on the map from native sources. There are no villages; the whole valley here is clothed with dense rhododendron jungle. The details of this reconnaissance will be looked forward to with much interest.

KENNETH MASON

REVIEWS

EUROPE

THE ARCHAEOLOGY OF CORNWALL AND SCILLY. By H. O'NEILL HENCKEN. (The County Archaeologies. General Editor: T. D. KENDRICK.) *London: Methuen & Co.* 1932. 7½×5 *inches;* xviii+340 *pages; illustrations and maps.* 10*s* 6*d*

The counties of England, slowly shaped by historical exigencies, often make awkward units for regional studies. The geographical range of each historical phase varies in detail from its predecessors so that investigations nominally undertaken within a single county must often reach beyond its borders at one moment and shrink within them at another. But the increased facility of working within these artificial limits for which the material may so much more readily be found gathered together in blue books, archives, or museums, nevertheless affords practical justification for regional studies on a county basis. To the famous Victoria County Histories there is now being added a series of County Archaeologies, and this volume by Dr. Hencken is perhaps the most successful so far produced.

Cornwall and Scilly as the maritime outposts of south-west England shared most completely in those Atlantic movements which throughout our history have balanced the more substantial contacts of the English plain with the continent of Europe. Dr. Hencken's survey shows how fundamentally the position of these regions has effected their settlement and cultures. They are well known for their remains of megalithic monuments, great funerary structures of cardinal importance as indices of the maritime expansion of the earliest agricultural and metal-working peoples up the Atlantic coasts of Europe. Dr. Hencken briefly sketches our present knowledge of this process and proceeds to a most valuable survey of the megalithic tombs in his area, supplementing the earlier work of Bonsor and Copeland Borlase with his own field studies. The wealth of Cornwall in tin gave it economic importance for long periods, but there is little direct evidence of tin working in Cornwall until the Early Bronze Age (*c.* 1700–1400 B.C.), when it was of paramount importance in maintaining an active commerce with Ireland in the west and Brittany in the south. But in the Middle Bronze Age (1400–1000 B.C.) there was an important deflection of traffic in Britain which is reflected in the rapid impoverishment of Cornwall. The Mersey became the great gateway from Ireland to Britain and the continent, and the Atlantic traffic seems to have fallen almost entirely away.

During the last millennium B.C. there was some revival of the western sea trade. Irish gold ornaments reappear in Cornish graves, axes of western French types are abundant in the hoards of this period, and a new type of pottery appears in south-western England, especially in west Cornwall. This Deverel-Rimbury ware derives from northern Iberia, whence it spread into south-western France. Its appearance in Britain is held by Dr. Hencken to indicate the establishment of the famous western tin route which survived into Roman times. It proceeded by sea to southern Brittany, in classical times to Corbilo, the famous port of the Venetii whose fleet was destroyed by Caesar, thence down the coast to the mouth of the Garonne, and upstream to the Carcassonne Gate, Narbonne, and the mouth of the Rhone.

Dr. Hencken's book is charmingly written and his descriptive material is supplemented by a most valuable archaeological gazetteer arranged by parishes.

The referencing could however be much improved; footnotes have apparently been deliberately avoided, but it is difficult from the bibliographical notes at the end of chapters to turn readily to the authorities for detailed points. The location of sites mentioned in the text is also often difficult on the folding-map or even on the 1-inch map, since parish names alone are given. To the local worker this presents no difficulty, but for the general reader reference to sites by direction from the few larger towns would have been of considerable help.

C. D. F.

THE VILLAGES OF ENGLAND. By A. K. WICKHAM. *London: B. T. Batsford* 1932. 9×6 *inches;* xii+52 *pages;* 106 *photographs*+16 *other illustrations; map.* 12*s* 6*d*

This is a companion volume to 'The Cottages of England,' and, as in that work, the letterpress is really subservient to the illustrations, which are of the uniform excellence associated with the firm of Batsford. As the reader turns from picture to picture, he may decide that this or that village must be the most unsurpassably lovely in the country, only to find a few pages farther on another that seems to reach a still higher pitch of perfection. But he must not neglect the letterpress; for in those fifty pages is a mass of orderly information and observant criticism. After some general remarks and a chapter on place-names the author proceeds to show that little is left of the mediaeval village except the church. He might with advantage have dwelt on the position of the church in most English villages; it seldom stands on a central site, but is often found on the outskirts, where however its tower forms the culminating point of the whole picturesque group.

The smaller domestic architecture that the unspoilt English village offers for our admiration was the product of the Tudor, Stuart, and Hanoverian centuries. Its style varied as much with locality as with period. The author bases his five divisions, chalk and clay, the limestone belt, the western midlands, the south-west, and the north, largely on the geological formation, but obviously there can be no hard-and-fast lines; the chalk and clay district must embrace the greensand of the Weald, and the northern area includes with the limestone of the Pennines rocks so different as the chalk of east Yorkshire and the green slate of the Lake District. The Pennines are often called the physical backbone of England, but the oolitic hills are shown to be the architectural backbone. The author gives much useful information on the actual quarries that supplied the material not only for local work but for some of the well-known buildings in our cities. In timber construction he points out the distinction between the finished designs of Suffolk and Kent and the artless, often monotonous, squares of the west midland cottages. The third great group of materials, brick and tile, is seen at its best in the eastern and south-eastern villages; their use was not general till a later date than the other two, and, as the author pertinently remarks, had no mediaeval inspiration like the architecture of the Cotswolds.

All the villages illustrated are marked by numbers on a useful but rather fierce geological map. This brings us to the one serious blunder in the book; the West Burton of the illustration and the text is the village, not on the lower Trent in Nottinghamshire, but in Wensleydale, west Yorkshire, as the hills in the picture, let alone the buildings, testify; no wonder it is said to "have a northern appearance"!

J. H. R.

ON FOOT IN THE HIGHLANDS. By ERNEST A. BAKER. *London: Alexander Maclehose & Co.* 1932. 7½×5 *inches;* 200 *pages; illustrations.* 5*s*

From its title it is obvious that Dr. Baker's book is intended for those whom he designates as "footfarers" (more popularly known as hikers), and it is a pity that

he insists on belabouring this point. He is not writing, he avers, for "unambitious folk . . . people who travel first class . . . deer-stalkers and grouse-shooters," and this sentence betrays the class consciousness which he unfortunately allows to colour his account of the Highlands. An attack on "rich sportsmen" seems out of place in a book which is presumably intended to be devoted to a description of tramps in Arran and Argyll, the Central and Eastern districts, the Cairngorms, Ross-shire, and Skye; and Dr. Baker seems to forget that even the thousands of hikers whom he pictures camping all over the countryside could not replace the sum spent in the country during one season by one of those "grouse-shooters" whom he so decries. From the point of view of the "footfarer" himself this book also leaves a good deal to be desired. Dr. Baker is apt to generalize rather than to give definite itineraries which the would-be rambler may follow. It is a difficult task to mix history, geography, and anecdote, and the author is apt to confuse his readers when describing, say, a trip along the Dunkeld road, by constant interpolations, and quotations from Sir Walter Scott, Christopher North, Burns, and other poets. Those who wish to know the best route across the Aonachs from Glen Nevis to Glen Spean will scarcely appreciate the verses beginning

"Come hither, Evan Cameron!
Come, stand beside my knee——"

while even the most ambitious hiker might scent melodrama in the lines:

"And curst be all who keep the Bens
For sheep and antlered rangers only."

Dr. Baker undoubtedly has a very real knowledge of the Highland districts, but he is too apt to confine his accounts of his former trips to a narration of incidents—humorous or otherwise—which occurred to himself and his companions; and surely the story of the man under the railway seat and the advent of the ticket collector is becoming rather a hoary chestnut? The author's style does not make for good reading. He is too fond of the cliché (one stretch of highway is, to him, a "veritable Pisgah") and his syntax is not above criticism. Those who are already well acquainted with the districts described here will doubtless be able to extract much valuable information from the book, but others, who have not already visited the Highlands, will probably prefer a work of more practical use. B. M. N.

ASIA

A CEYLON COMMENTARY. By P. R. Smythe. *London: Williams and Norgate* 1932. 7½ × 5 *inches; 184 pages; sketch-map. 6s*

A career in the junior grades of the Ceylon Civil Service extending over twenty months and ending in a "hasty and premature departure" is but a slight experience on which to construct a criticism of that Service and of those who fill its ranks, as well as a Commentary embracing, not only Ceylon, but India and the profoundly intricate and difficult subject of the relations of white with coloured peoples. But the author of this little book has gallantly attacked these challenging and complex matters and to dismiss him unread because of his manifest inadequacies would be to forgo something of interest. For the book presents an arresting study of the reactions of a young man thrust by unkind fate into entirely uncongenial surroundings. Captious and full of self-complacency, contemptuous of the sports, games, and other social amenities essential to European life in the tropics, the author seems to have arrived quickly at that unhappy state of mind in which little appears right and most things wrong, in

which errors of the Administration and its officers, the abominations of the white inhabitants, iniquities of the native population, and shortcomings even of wild Nature herself, are ever present, while the efficient, the virtuous, and the beautiful pass unnoticed.

In the first chapter, under the invidious heading "Colour," the writer, referring only incidentally to Ceylon, sets forth his views on the inter-racial question of the Orient in its social and political aspects. Unfortunately any possible value in his profuse remarks on the first of these aspects is discounted by their studied acerbity, while his disquisitions on politics, of India especially, being founded mainly on hearsay, bring little that is new to the discussion of these important matters. The remainder of the volume contains an account of the writer's brief period of service in Colombo and various outstations of Ceylon, with animadversions on the people and institutions of the country. The irritation caused in the reader by the author's persistent mordacity is aggravated by an annoying literary ineptitude or carelessness that pervades his book. Of this three examples, taken at random from amongst the many, may be cited: "Before he has scarcely left the Custom House" (p. 20); "an unbridged and so impervious river" (p. 128); "It is not pleasant to watch a man's back become transparent through an adhesive shirt or to be splashed with guttering sweat" (p. 85).

That this book was written at all may appear to some regrettable; but it would be wrong to discourage the author, for he is stout-hearted and in earnest, and, with further cultivation of the art of writing and of the virtues of tolerance and restraint, may well produce useful work. W. A. G.

A TOWER OF SKULLS: a journey through Persia and Turkish Armenia. By GERALD REITLINGER. *London: Duckworth* 1932. 9×5½ *inches;* 336 *pages; illustrations and sketch-map.* 18*s*

Mr. Reitlinger has written amusingly of his cheerful progress through 4000 miles of Persia and Turkish Armenia. He has bumped in a series of Ford cars, or on the backs of various beasts, from Mosul to Baghdad, from Baghdad to Hamadan and Isfahan, Shiraz and Shapur, then northwards to the Caspian *via* Isfahan again and Tehran, along the coast to Resht, and thence to Tabriz and Urmia. Finally his tour takes him through Bayazid and Kars to Trebizond.

He is a pleasant and easy companion and has a happy knack of acquiring curious, if not very profound, pieces of information about the artistic, archaeological, and historical points of interest in the places he visits. He has a keen eye and a ready humour, although his efforts to bring the East home to the reader by analogies with the West are sometimes a little laboured. His tolerance and sympathy pull him through many misadventures exasperating to a European. Detained in Turkish Armenia as a spy and subjected to every kind of discomfort, he still observes his surroundings (and particularly his military escort) with a keen and indulgent eye. This is the best part of the story. The lover of the Middle East will enjoy this book and the casual traveller there should take it with him. It is plentifully illustrated with excellent photographs by the author. E. H. K.

ON THE ABORIGINAL INHABITANTS OF THE ANDAMAN Islands. By EDWARD HORACE MAN. With report of researches into the language of the South Andaman Island, arranged by ALEXANDER J. ELLIS. Reprinted from the Journal of the Anthropological Institute of Great Britain and Ireland. [Republished with Introductory Note by Miss A. F. MAN.] *London* (1932). 9×6 *inches;* xxxii+224+74 *pages; illustrations and map*

Published originally in the Journal of the Royal Anthropological Institute in 1882–3, and issued shortly after in book form, Man's account of the Andaman

Islanders has been out of print for many years. Although Mr. A. R. Brown's monograph on the Social Anthropology of the Andaman Islanders has appeared in the meantime, the Royal Anthropological Institute has performed a very valuable service in reissuing Mr. Man's book, with a more comprehensive series of photographic illustrations. It not only set new standards of accuracy and objectivity when first published, but must remain the classic work on these people since Man was able to gather his information before European settlement had been sufficiently prolonged to disrupt the native life and decimate the population.

The Andamanese are a negrito people racially fairly homogeneous and closely related to the Semang of Malaya, the Aeta of the Philippines, and other pygmy stocks found in the interior of the islands of Indonesia. Like the other pygmy negroid stocks the Andamanese formed small communities of hunters, each group of thirty to fifty people occupying its own small section of forest or shore. Between the coastal and forest sections there was an active interchange of products, particularly turtle on the one hand and wild pig on the other.

But the simplicity of negrito life was modified among the Andamanese by the possession of a few elements of more advanced material equipment, including pottery and outrigger canoes and a more elaborate ritual organization than existed among their congeners. Their relative proximity to the Burmese and Indian mainland and the records of castaways in the historical period make it probable that these unusual elements were accretions received from time to time when individuals or small groups from mainland cultures reached the islands and introduced practices some of which were adopted into the primitive food-gathering economy. The comparative problem thus raised was not considered by Man, but his data must necessarily be of importance when the manner in which these more elaborate crafts and customs appeared among the negrito people is seriously investigated. C. D. F.

AFRICA

MEN OF THE TREES. In the mahogany forests of Kenya and Nigeria. By Richard St. Barbe Baker. *London: George Allen and Unwin* 1932. 9×5½ *inches;* 282 *pages; illustrations.* 12*s* 6*d*

Among civilized races the love of trees is probably even wider spread than that of animals. Uncivilized people delight in destroying trees, with the exception of specially selected ones which are believed to shelter ancestral spirits. This destructive propensity is not however due to wantonness but to the desire for access to fresh areas of virgin soil wherein to plant crops. The results of this practice are disastrous wherever practised, and particularly so in Africa.

Like all keen forest assistants, the author was vastly troubled by forest demolition and had the idea of checking it by the formation of an organization based on that of the Boy Scouts. In the early part of this work he vividly describes his efforts to inspire the Kikuyu tribes of Kenya Colony to become planters of trees instead of destroyers. The method was novel, but this gospel had been preached for years previously by a succession of District Officers; so that it was no new idea, but undoubtedly came as a useful stimulus. Unfortunately however the author's sojourn in Kenya was too brief to ensure the permanent success of his plan, but it is pleasing to learn that under the guidance of the administration the local Native Councils are now carrying on the work of tree planting, even though the temporary enthusiasm for a special Guild of Youth for this purpose has waned. From East Africa the author was transferred to West Africa and his description of the collection of mahogany logs is full of interest.

Some of this work must have been written for American readers, and it is curious to read that "The average American seldom realizes all that he owes to tropical Africa." Why American? It seems a little invidious to single out the people of U.S.A. as being ignorant of that great continent. It also seems a little out of place in a book on forest protection to include a chapter advertising the profitable prospects of coffee-growing, excellent though they may be. A little consideration will also demonstrate that the author's suggestion that wireless is likely to prove a very valuable adjunct in the education of the native is not of great value; these short cuts are fraught with disillusion and only produce superficial results. The author alleges that he was responsible for the discovery that the East African juniper was suitable for pencils; this is incorrect, and must be a lapse of memory, for juniper pencil slats were exported in bulk from Kenya for some years previous to his arrival there, and the suitability of the wood has been known for over thirty years.

There is however much that is suggestive in Mr. Baker's book, and one cannot fail to be struck by the enthusiasm with which he preaches his gospel of forest conservation; it is hoped that it may have an appreciable effect. C. W. H.

AUSTRALASIA AND PACIFIC

GREAT BARRIER REEF EXPEDITION 1928–29: Scientific Reports. Vol. III, No. 2. The Structure and Ecology of Low Isles and other Reefs. By T. A. STEPHENSON, ANNE STEPHENSON, G. TANDY, and M. SPENDER. *London: British Museum (Natural History)* 1931. 12×9 *inches; pages* 17–112; *illustrations and maps.* 20*s*

In this paper the authors give an account, including both the physical features and ecology, which latter has been described as "the fascinating intricacy of the intimate life of every-day creatures," of certain islands and reefs. Their investigations were especially directed towards the elucidation of problems which have a direct bearing on ecology and, as the authors point out, "the characteristic distribution and relations of common organisms may give a geologist or geographer the key to some variation in the surface morphology of a reef, which may be fundamental." In all coral formations the twin processes of construction and destruction are proceeding simultaneously and a study of the latter phase is as important as the former; it is therefore regrettable that the expedition did not give more attention to the commensal and concealed life of the coral platforms and living coral, and especially to the boring organisms, these latter being of great importance in the study of the destructive processes. It is also unfortunate that in their description of certain features of these islands and reefs they have not exercised more discrimination in their use of terms; thus, according to the definition given on p. 101, the term "coral rock" is used to include (*a*) a secondary rock composed of fragments of coral that have been thrown up by wave action and have subsequently been cemented together to form a shingle-conglomerate; and (*b*) boulders of dead coral that may have been torn from their original position and have been thrown up on the shore or may possibly have died off but still be *in situ;* in any attempt to trace the changes that are and have been going on in a reef it is essential clearly to discriminate between these various structures. Equally essential in the interpretation of the surface morphology of a reef is the correlation between the present physical features and the changes of sea-level that are known to have occurred in the not far distant past; but this problem has been entirely ignored. Every coral reef and island must be judged individually and allowances made for differences in local conditions, etc., and possibly also

for the different outlook of individual observers, but the authors' claim that Low Isles, on which their attention was mainly concentrated, is "as near to being as typical a coral reef as many another" will not be admitted by some, for their description, as well as the results of borings, shows that the coral growth is clearly a veneer on a mud bank; the seaward zone all round, with the possible exception of an area on the north and north-east side of the anchorage in which there may be a reef-face, the coral growth on this side appearing from the chart to drop steeply to the bottom in 15 feet of water, consisting of an area of "foul-ground," plentifully dotted over with coral-heads. In the great majority of coral reefs there are certain zones that can be recognized, the reef face being the outermost; in Yonge Reef the so-called "outer rampart" seems to correspond with the nullipore or lithothamnion zone and the "outer moat" to the buttress and trench zone of other reefs; but the "boulder zone," such as one finds in exposed reefs in the Maldives, appears to be lacking, for the authors describe the reef-crest as being swept clear of debris, though this would seem to be variable, for in another place they remark, "where boulders do occur, etc." The zone that the authors term the "boulder zone" lies in both Yonge reef and Low Isles on the west or north-west side, and, according to them, has been derived from masses of coral torn off the area of foul-ground on that side and flung up by storms from the north-west; but the photographs that they give suggest that some at least of these dead masses may be part of an older growth of coral that is still *in situ* and lived at a time when the sea-level was higher than it is to-day, but have not yet been completely eroded away, and to this possibility the authors do not seem to have paid sufficient attention.

In his summary of the supposed history of Low Isles T. A. Stephenson concludes that this area commenced as patches of reef, similar to those found at the present day round Lizard Island; on reaching the surface the top was killed off, leaving only the seaward slopes, around which a "windward pavement" was formed on the south-east side; later the sand cay and mangrove swamp arose, and the shingle ramparts were thrown up. The presence of beach-sandstone around the sand cays on both Low Isles and Three Isles seems to indicate that these are being eroded away and the shoal area to the north-west side of Low Isles may well be due to the deposition of sand and mud derived from the erosion of this island and flat. Finally, it seems from the account by no means improbable that the differences in the surface features of Yonge Reef, Batt Reef, Low Isles, and Three Isles form a graded series directly correlated with the degree of exposure as the outer edge of the Barrier is approached, the degree of erosion being greatest in Yonge Reef and least in Three Isles, which, though occupying the same inner zone as Low Isles, possesses a larger sand cay and still shows traces of the old reef level in the so-called "raised pavements." While their account of the ecology of the reefs will be of great interest and value to zoologists, the authors seem to have refrained from putting forward in this volume any conclusions regarding the causation of or the differences between the surface features of the reefs; they have aimed at giving so detailed and accurate an account that readers may form their own conclusions, thus ignoring the fact that such cannot possibly carry the same authoritative weight as conclusions drawn by observers who have spent over a year among these reefs. R. B. S. S.

[But it should be added that there is some discussion of these conclusions in two papers published in this *Journal* by Mr. J. A. Steers (vol. 74, 1929, pp. 232–257 and 341–370), and by Mr. Michael Spender (vol. 76, 1930, pp. 193–214 and 273–297).—Ed. *G.J.*]

A GEOLOGICAL MAP OF THE COMMONWEALTH OF AUSTRALIA.

By Sir T. W. EDGEWORTH DAVID. *4 sheets in container.* Together with Explanatory Notes. *Sydney: The Commonwealth Council for Scientific and Industrial Research, by permission of Edward Arnold & Co. of London* 1932. 10×6 *inches; 178 pages; diagrams and maps.* 42*s*

As stated in the modest preface to the Explanatory Notes, this map has taken seven years to complete. To those who can appreciate the vast size of the Commonwealth this will cause little surprise, and still less to those who know the author's passion for accuracy, and his ceaseless activity in a variety of spheres. It was characteristic of Professor David that he should delay the completion of both the map and his larger work to visit some of the more inaccessible parts of Australia. Although based on the geological maps of the individual states, the map is much more than a mere compilation of data already in existence. Not only has the author personally visited most of the areas in the map, but he is a past master at generalization and correlation. From the point of view of a geologist there are perhaps several points for criticism, for the author is well known for his fearless and brilliant hypotheses. On the other hand the geographer, who will not care to follow the map down to details of correlation, or question too closely the recognition of pre-Cambrian fossil remains, will find very little indeed to feel uneasy about. The book of Explanatory Notes, being a condensed description of the geology depicted on the map, is in places highly technical, but the deductions to be made from the mass of technical facts are always clearly stated. To the geographer the last chapter, a historical review of the region, is particularly valuable. A great deal of it is admittedly hypothesis, but written in the author's dramatic style it gives what so few geologists dare to give, a picture of past events which must in the main be correct, a brilliant, if uncertain, study in palaeogeography.

The map itself is on a scale of 1 : 2,990,000, and is printed on four sheets, which can be mounted to form a large map about 7 feet long by 6 feet broad. It is not intended for use as a wall map however, though its broad splashes of colour do, in fact, outline the continent fairly well. The boundaries chosen are wide enough to include the greater part of New Guinea, and the interesting arc of islands to the west, as far as Java. The choice of colours, based on the traditional range of colours for geological maps, seems to be very happy. The only improvement of importance that can be suggested is that the white areas of land in Australia and the non-British islands might have been coloured a very faint neutral tint, so as to distinguish them from the seas and lakes. The meticulous cartographer will probably object to the large number of place-names, and the heavy lining of the railways. Both must appear, for purposes of reference and location, but the type used is perhaps unnecessarily heavy.

The large areas of sea on the map have been utilized for what to the ordinary geographer is perhaps the most useful feature of all, namely a number of sections printed in colour. A multitude of Professor David's old students all over the world will recognize in these the hand of their teacher, and remember his skill on the blackboard. Naturally geological sections in a country as yet so sparsely mapped must be full of conjecture and hypothesis, but they do interpret the plan in a vivid way, and the author has not departed from his earlier manner in boldly adventuring an explanation of surface features in this way. The elaborate legend at the base of the map is in itself a condensed correlation of beds in different states. Other insets include a large-scale map of Tasmania, and part of the Mandated Territory of New Guinea.

The whole production reflects credit on the originators, and adds yet more honour to the veteran geologist of Australia. F. D.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

THE PRINCIPLES AND PRACTICE OF GEOPHYSICAL PROSPECTING: being the Report of the Imperial Geophysical Experimental Survey. By A. B. BROUGHTON EDGE and T. H. LABY. *Cambridge: University Press* 1931. 11 × 8½ *inches;* xiv + 372 *pages; illustrations and maps.* 15*s*

As a result of a report issued in 1927 by the Committee of Civil Research the Imperial Geophysical Experimental Survey (I.G.E.S.) was constituted in February 1928 for the purpose of conducting thorough trials of the principal geophysical methods and of determining their practical value and limitations under a variety of geological conditions. Eighteen months' fieldwork was done in Australia, and the book before us is primarily a report on that work. In Part I the investigations made in various areas, scattered over all the Australian States, are described and the results compared with the information already obtained by mining or boring. In one case four new borings were made subsequently to a gravitational survey and confirmed it to a remarkable degree. Practically every available method was employed, and an elementary explanation of the basic principles, the instruments used, the field procedure, and the interpretation of results is given in such a form that it can be followed, without specialized knowledge of mathematical physics, by mining engineers, geologists, or any one to whom a geophysical survey can be of use or interest. In Part II the instruments are described in detail, with some suggestions for improvement, and the mathematical calculations on which interpretation is based are fully worked out. In conclusion the detailed costs of each investigation are discussed. From this book it should be possible for a Government Department or a commercial firm to ascertain whether a given problem is amenable to a geophysical approach, the particular method or methods of prospecting likely to be suitable and a rough idea of the probable cost. It may therefore be regarded as a standard work on the whole subject covered by the title. In view of the amount of information and the wealth of explanatory diagrams and photographs the price is small.

Of electrical methods of prospecting five representative systems were fully investigated. All depend upon the existence of well-marked differences in electrical conductivity, either between ore-bodies and the rocks enclosing them or between contiguous geological formations. In addition to the obvious application to the search for such minerals as the sulphide ores of copper, lead, and iron, the results obtained show that, under favourable conditions, it is possible to make satisfactory determinations of the depth to the water-table or to bedrock in country covered by recent and unconsolidated formations. A valuable table of the resistivities of rocks and minerals is given, but it is pointed out that these are for laboratory specimens; in actual practice the figures depend to a large extent on the amount of water present in the body of the rock or in fissures. The depth to which electric methods are effective is also largely dependent on this factor, and it is a great advantage to have an authoritative decision on this question based on the wide and varied experience gained in Australia: "it is the opinion of the I.G.E.S. that there are very few mineral fields in which the expense of an electrical survey would be justified unless substantial ore-bodies are to be expected within 250 feet of the surface."

Of one interesting application of surface-potential methods further investigation is recommended, with slight modifications of the apparatus. "Where water of various salinities may occur at three or four different horizons, it should be possible . . . to make a distinction between them and, possibly, to locate the horizon at which the salinity is at a minimum." A suitable area for such work at home might be found in the Vale of York, where the Triassic rocks beneath a

cover of drift have yielded waters differing by more than 100 degrees of hardness from bore-holes not many miles apart.

One example where new information of direct economic value was obtained may be mentioned. An equipotential-line survey was carried out in the graphite mining area of Port Lincoln, South Australia, and an important anomaly was discovered. From an old prospecting shaft a cross-cut was driven to prove the ground and a new graphite lode was encountered. The Director of Mines, when reporting this result to the Survey, concluded by saying, "the results generally must be regarded as complete proof of the suitability of the geophysical method employed for the exploration of this particular type of concealed graphite deposit."

It is noticeable that more space is given in the book to the electrical methods than to the gravimetric, magnetic, and seismic methods combined. The details of electric methods, apparatus, and results are the more valuable in that, previous to the work of the I.G.E.S. and the publication of the report, very little information was generally available. The makers of the various types of instrument made their own surveys and did not make their experience and knowledge public. The report of the Committee of Civil Research already mentioned suggested that "a full disclosure of the scientific facts would tend, more than anything else, to stimulate the natural development of this method of geophysical surveying by placing it on a scientific footing, similar to that of the gravimetric method." This full disclosure has now been made.

The gravimetric method has already been extensively used for the determination and delimitation of faults and folds, but except for lignite and salt is seldom of direct use for the tracing of minerals. A table of densities is given, but metallic minerals, though heavy, are seldom concentrated in sufficient quantity to be discovered by a torsion balance or gradiometer. The most interesting results obtained by the Survey were in the lignite field of Gelliondale, Victoria; a considerable amount of new information as to the extent of the "coal" was obtained and subsequently confirmed by boring. In one case the record of an old boring was incompatible with the gravimetric determinations; a new hole was put down at the site and the old record proved to be erroneous. On the other hand several disadvantages are noted. The torsion balance was difficult to transport, could only be used at night and then only in an auxiliary protecting hut; the work was therefore slow and consequently costly. The gradiometer used was more easily transported and quicker in working, but the torsion wires supplied were unsatisfactory, necessitating frequent and tedious calibration. If the publication of the experience gained leads to an improvement of the instrument, its value is obvious; in fact, a footnote states that an improvement of design, giving a very simple adjustment of the balance of the beam, has already been made.

The magnetic method has long been used for the detection of masses of magnetite and other highly magnetic ores, but other applications of economic value are rare. Consequently but little work was done in Australia; a survey at Gelliondale, subsidiary to the gravimetric survey just mentioned, led to the detection of a previously unknown basaltic intrusion.

Seismic work was also somewhat limited; its value is well indicated by the statement that twenty-seven weeks were devoted to research on the instruments and methods, and only eleven weeks to trial runs. For the latter the Gulgong goldfield of New South Wales was selected: here the depths beneath a cover of alluvium to a bedrock of granite and slate were determined and the course of metalliferous lodes mapped out. Important suggestions for the improvement of the instruments are made.

In the last chapter the general conclusions as to the types of problems to which the various methods of geophysical surveying are best applied should be of the greatest value; five electrical methods are discussed separately. A final section deals with working costs. It is suggested that, owing to the heavy wear and tear resulting from transport over rough country and to the rapid improvement in design to be expected, the capital cost of instruments should be written off in two years. Only in the seismic method is there any important expenditure on material used; it is estimated that explosives would always account for half the cost of a survey. The cost of the surveys in Australia was shared by the Empire Marketing Board and the Commonwealth Government, each contributing £16,000. The report makes it clear that the money was well spent. C. N. B.

CARTOGRAPHY

SURVEYING. By W. NORMAN THOMAS. Third Edition. *London: Edward Arnold & Co.* 1932. 9×5½ *inches;* viii+552 *pages; illustrations.* 25*s*

All British surveyors will extend a hearty welcome to the third edition of this very comprehensive book. A first glance at the chapter headings, which include details of almost every branch and twig of the art of surveying, suffices to convince the reader that he has in his hand a book whose very scope alone makes it essential as a book of reference. This glance at chapter headings however at once draws attention to the curious sequence in which the book is drawn up. Chapter I deals with Chain Surveying, and it is not until Chapter XIII is reached, some 370 pages later, that we find any reference to Triangulation, which itself is followed by that on Base Measurement, and preceded (by over 100 pages) by a chapter on Plane Tabling. It would have been advantageous to have arranged the book in a more logical sequence, if only to emphasize the fact that chain surveying, and indeed all sorts of surveying for engineering ends, are in reality members of the same big family, whose parents are of necessity the main geodetic framework on which all surveying is or should be based. Chain surveying is followed by chapters on Magnetism and Optics, and on instruments generally. This leads up to a full and explicit chapter on Theodolites, in which however too much space appears to have been devoted to instruments of antiquated pattern, and to small vernier instruments which, while being of some value in tracing lines, are of no interest in modern triangulation. A short reference is made to the Tavistock Theodolite in an appendix, for further details of which the reader is recommended to two publications on neither of which he is likely to be able to lay his hands at short notice. A fuller description of this excellent instrument would not have come amiss.

A chapter on Theodolite Surveying which confines itself to angular measurement in traverses, linear measurement having been dealt with earlier in the book, is followed by chapters on levelling, tacheometry, and range finding. The chapter on Plane Tabling is not up to the high standard set by the remainder of the book and conveys the impression, perhaps wrongly, that the author is far from enthusiastic about this particularly valuable branch of the Survey Art. It is under a later chapter, namely Hydrographic Surveying, that mention is made of instrumental resection, which is there somewhat inadequately described. Triangulation, followed by base measurement, is very adequately dealt with, and the chapters devoted to Astronomy are excellently clear and straightforward. The final chapter in the book, dealing with Aerial Surveying, is the least satisfactory. Surveying of detail and contours is dismissed in a few words, followed by the author's conclusion that "Aerial Surveying is still in its infancy." Possibly,

but it is indeed a lusty infant that has produced a 24-sheet series of 1/20,000 maps contoured at a 10-metre interval covering the whole of Hong Kong and the New Territories, to mention but one of the actual and tangible results obtained by the Arundel method of air photo survey achieved during the last five years. J. C. T. W.

ECONOMIC AND HISTORICAL GEOGRAPHY

CRISTOFORO COLOMBO. By C. DE LOLLIS. (Opere. Tomo I.) Edited by Professor R. ALMAGIÀ. *Milan: "La Cultura"* 1931. 8½×6 *inches;* xxvi+426 *pages. Lire* 25

The name of de Lollis among Columbian authorities will always command respect, if only for his editing of Columbus's autographic *adversaria* for the great "Raccolta Columbiana." His acceptance of these at their face value largely caused him to become a keen supporter of the traditional view of the discoverer's life and achievements, and the case for this standpoint is set forth lucidly in his popular life of Columbus here reprinted. Though it may not now be possible to accept these views in their entirety, it is useful to have the conservative view clearly stated in opposition to the iconoclasm of the Vignaud school. This first volume of his collected works contains the life, first published in 1892, with four more controversial pieces devoted mainly to upholding the thesis that Columbus's aim was to reach Eastern Asia by sailing westwards. Professor Almagià's introduction surveys the recent trend of criticism, and defends de Lollis's position skilfully. He finds little difficulty in dismissing the wilder theories of Ulloa, Larsen, and others, and accepts the general trustworthiness of Ferdinand Columbus's 'Historie'—though he admits that the latter requires some emendation, and that the supposed Columbian chart discovered by M. de la Roncière could have served Columbus on his first voyage. On the point of Columbus's seamanship and general scientific outlook however he is unyielding. He concludes by expressing the opinion that the time for minute discussion of details of Columbus's life has passed, and that the task before modern scholarship is the examination of the contemporary scientific outlook, and the effect upon it of the discovery of America. When this outlook is examined however it becomes difficult to accept all the claims made by the supporters of the traditional Columbus. G. R. C.

BOUGAINVILLE: soldier and sailor. By MAURICE THIÉRY. *London: Grayson and Grayson* 1932. 8½×5½ *inches;* 292 *pages; illustrations and sketch-maps.* 15*s*

Bougainville's fame, with the general reader, rests upon his voyage round the world. Until this translation of M. Thiéry's work there has been no comprehensive account of his life in English. The circumnavigator had other claims to distinction. He had served as a soldier under Montcalm in Canada, witnessing, not for the last time, the muddling inefficiency of French administration, and loathing the savagery of France's Indian allies. He later took to the sea, and founded a promising colony in the Falkland Islands. Within a few years he had to hand it over to Spain—a mortification he alleviated to some extent by his voyage round the world. He also won some distinction as a mathematician, and planned a voyage of Arctic exploration. In disposition adventurous, inquiring, and romantic—after the school of Rousseau—he was a typical eighteenth-century figure. His theoretical admiration for the noble savage was rudely shaken in Canada, and it was no doubt the strong contrast of native ways that enamoured him of the South Seas. He must have felt keenly, on his return, the criticisms of the philosophers that he had contributed to the destruction of the

Paradise of those idealized waters. M. Thiéry, drawing upon family papers, has told his story straightforwardly, though with an occasional lapse into the technique of the novelette. His admiration is perhaps a little uncritical—Bougainville was hardly "one of the most amazing personalities the world has ever seen"—and the circumnavigation might have been placed in its historical perspective. The translation sometimes betrays too close a parallel with the French original. "William Sampier," who finds his way even into the index, ought not to have gone uncorrected. G. R. C.

GENERAL

UNITED STATES GEOGRAPHIC BOARD: First Report on Foreign Geographic Names. *Washington: U.S. Government Printing Office* 1932. 9×6 *inches; 113 pages.* 10 *cents*

The great majority of the decisions of the U.S.G.B. have hitherto been concerned with the names of places in the States themselves and in their dependent territories; but there have appeared from time to time, *rari nantes in gurgite vasto*, a few foreign names selected, it may be supposed, on no regular principle except that government departments have happened to request official rulings on their orthography. These were apt to be overlooked in the published lists, and it was a wise decision of the Board about four years ago to place foreign names in a separate category and to appoint a committee to investigate the whole subject. The first work of this committee was to consider principles and to formulate rules. In this they found the ground well cleared for them by the Permanent Committee on Geographical Names for British Official Use, with whom they have always been in close co-operation, and they took for the basis of their policy the R.G.S. II System, together with R.G.S. Technical Series No. II. The two main points where the U.S.G.B. has differed from the P.C.G.N. are (i) in the rendering of native (African, Oceanic, etc.) names in the colonies of the European Continental Powers, where the U.S.G.B. follows the official usage of the governing country, *e.g.* Djibouti, and the P.C.G.N. transliterates into an English form, *e.g.* Jibuti; and (ii) in the transcription of two letters in the Russian alphabet, the U.S.G.B. writing *zh* and *y* where the P.C.G.N. writes *j* and *i*. In the rule of procedure in absence of a published decision of their own the U.S.G.B. directs the use of the national postal guide of the country concerned, then, with caution, of the international 'Dictionnaire des Bureaux de Poste,' and, failing these, of the Lists published by the P.C.G.N.

For the first time in U.S.G.B. publications an attempt has been made to indicate pronunciations; but the Pronunciation Key differs considerably in respect of vowel sounds from the Transliteration Table, which is the R.G.S. II System slightly modified. It is to be feared that this arrangement may lead to confusion, *e.g.* transliteration Zinovievsk but pronunciation zē-nô′vyĕvsk.

The thirty pages of introductory matter set forth with admirable clearness the problems involved in spelling foreign names and the policy adopted by the U.S.G.B. for their solution. The new Turkish alphabet and the Nippon Romazikwai system of transcribing Japanese have both come under special consideration, the former being adopted and the latter rejected in the Board's decisions. The list of names, itself occupying seventy-two pages, embraces the whole world outside the territories of the U.S.A. It is not clear why certain English names are included, as their orthography would not appear to be in doubt and their pronunciation is not given. It is true that "Wimbledon, a S.W. suburb of London," has a certain interest for Americans; but what are the alternatives? J. H. R.

THE MONTHLY RECORD

MOUNT EVEREST EXPEDITION, 1933

The Chairman of the Mount Everest Committee has received from the Keeper of the Privy Purse the following letter:

"The King read with much interest of the characteristically British decision of the Mount Everest Committee composed of the Royal Geographical Society, the Alpine Club, and the Himalayan Club, not to be content with the achievements of men like Mallory and Irvine, who lost their lives in their attempt to reach the summit of Mount Everest, and of Norton and Somervell who so nearly succeeded, but to equip and send out yet another expedition next year. The experiences of Colonel Howard Bury, General Bruce, and Colonel Norton should, His Majesty feels, be of great assistance to the members of this fresh expedition, and enable them to overcome the appalling difficulties which have hitherto proved insurmountable.

"It was with great satisfaction that the King heard that Mr. Hugh Ruttledge had been appointed Commander of the expedition, as his knowledge of mountaineering and intimate acquaintance with the Himalayan people and Tibetans renders him eminently fitted for this post. His Majesty wishes him and the party of twelve who will accompany him every success, and will follow their movements with the keenest interest.

"The King knows that expeditions of this nature require careful and costly preparation, and desires me to send you the enclosed cheque for £100, which he wishes to give towards the expenses."

The Committee have invited the following gentlemen to join the expedition: Captain E. StJ. Birnie, Major Hugh Boustead, Mr. Colin G. Crawford, Doctor Raymond C. Greene, Mr. P. Wyn Harris, Mr. J. L. Longland, Doctor W. W. McLean, Mr. N. E. Odell, Mr. E. O. Shebbeare, Mr. E. E. Shipton, Mr. F. S. Smythe, and Mr. G. Wood-Johnson.

THE BROADCAST WEATHER SHIPPING BULLETIN

In Admiralty Notice to Mariners No. 1499, dated 21 September 1932, the Hydrographer of the Navy announces an interesting addition to the Weather Shipping Bulletin, broadcast on 1554·4 metres from Daventry at 11 p.m. on weekdays and 9 p.m. on Sundays. Following the weather bulletin and gale warnings there will be when occasion requires navigational warnings, of casualties to lights and extensions to shoals. These warnings are additional to the established warnings given by the Post Office coastal stations in Morse Code, and are intended for the use of coastal shipping and fishing vessels not carrying a wireless-telegraph operator. But they will also carry inland a refreshing breath of the sea.

SCOTTISH AND GERMAN MOUNTAIN CLIMATE

In a paper "Der Rückzug der letzten Vergletscherung: Eine vergleichende Betrachtung," Professor Johann Sölch, of Heidelberg, gives an interesting comparison of climatic conditions as bearing upon glaciation, in the Highlands of Scotland and the so-called Mittelgebirgen of Germany (*Sitzber. Heidelberg. Akad. Wiss.*). It is represented that, whereas the Alps are still in the late glacial stage, the German Mittelgebirgen have been post-glacial for a considerably longer time than the Scottish Highlands, which to-day are free of glaciers by only a narrow climatic margin. Thus, in the German mountains there are no permanent snow-beds as there are in Scotland, the vegetation belts climb to higher levels, and even in the Riesen Gebirge the extent of rocky wilderness around the Schneekoppe (5200 feet) is markedly smaller than about Ben Nevis (4400 feet).

That climatic conditions in the Highlands are more severe both in respect of cold and storminess is further illustrated by comparative statistics for the period 1888–1903 between Ben Nevis and the Feldberg, the highest summit of the Black Forest, exceeding the Ben by about 500 feet. On the Feldberg the mean temperature exceeds the freezing-point during the seven months April to October, and the July mean is as high as 51° F., but on Ben Nevis it exceeds freezing only for five months, May to September, and the July mean is only 41° F. January is the only month when the Feldberg is not warmer than Ben Nevis, the mean temperature of both summits being at 24° F.—the lowest in the year. As the average winter temperature reduced to sea-level in Scotland is rather higher than anywhere in Germany the disappearance of the excess at 4000 feet illustrates what, indeed, is known, that the temperature decreases more rapidly with height in the British Isles than on the Continent.

Finally, making use of a formula devised by H. W. Ahlmann for the mountains of Norway but presumably applicable in neighbouring regions, connecting the height of the snow-line with summer temperature and annual precipitation, Professor Sölch finds that the summer temperature of the Feldberg could drop 8° or 9° F. without bringing the snow-line down on to the Black Forest unless at the same time there were a considerable increase in the snowfall, whereas a drop of only 2° or 3° F. in the summer temperature of Ben Nevis would, with the heavy precipitation, suffice for the development of glaciers in the Grampians.

HOFS-JÖKULL AND LANG-JÖKULL, ICELAND

Although 13 per cent. of the surface of Iceland is covered by snowfields and glaciers they have been very little explored, and hence a paper by Joseph Keindl entitled "Untersuchungen über den Hofs- und Lang-jökull in Island," in the *Z. Gletscherk* for March 1932, is welcome.

The two ice-sheets named are in the very centre of Iceland to the west of the great Vatna-jökull. While the area of the latter, 8500 square kilometres, is more than double the total ice area of the Alps, that of the Hofs glacier, 1350 square kilometres, and also of the Lang, 1300 square kilometres, equals the total extent of ice and snow in the Austrian Alps. Keindl's visit has thrown light on the somewhat vexed question of the relation of the vast development of ice-sheets in Iceland to the present climatic conditions of the island. The surface of the Hofs-jökull is at an altitude of 1600 metres, but the snow-line in the locality is estimated at 1300 metres, and as the underlying rock only attains or exceeds the snow-line at a few points there is thus a great thickness of ice. Similar conditions obtain in the Lang-jökull, where the snow-line appears to be somewhat lower at about 1100 metres. From these observations the author infers that though the present snowfall suffices to preserve Iceland's vast glaciers, it would not suffice to create them. According to this view, therefore, the Icelandic glaciers are shrunken relics of the past, are able to preserve themselves because the ice itself raises considerable areas above the snow-line, but, if removed, would not in present climatic conditions reform to anything like their present dimensions.

THE DELTA OF THE TIBER

An elaborate study of the morphology of the Tiber delta, the changes to which it has been subject, and the conditions making for such changes, has been published by Dr. A. D'Arrigo in the *Annali dei Lavore Pubblici*, 1932, Fasc. 3, under the title "Sulle Fasi di Regime del Litorale Deltizio del Tevere." The study does not lend itself readily to analysis, but some of the writer's results and conclusions may be briefly recorded. The delta is divided into two roughly

equal parts by the principal mouth, at the apex of the triangle formed by the deltaic material in the centre of the old shallow bay stretching from Capo Linaro in the north to Capo d'Anzio in the south. It is pointed out that a straight line joining these points passes exactly through the apex of the delta and that the general direction of the principal mouth is normal to this. Attention is paid to the quarters of the compass to which the shore-line of the delta is exposed, and to the extent of open sea stretching in various directions, as this has a bearing on the action of winds and currents. The divergent directions taken by the subsidiary mouths in the north and south is noted, and is held to have an important bearing on the causes of the changes now at work. The distances to which sand and other material can be moved along the sea-bottom at considerable depths is also considered, after which the author discusses the past changes of coast-line that can be substantiated, particularly within the past two centuries. The more exact knowledge dates from the survey by Chiesa and Gambarini in 1744. During this period at least there is definite indication of corrosion of the outstanding part of the delta, and the writer appears to connect this with the position of its apex in relation to the fixed points to the north and south already referred to. A similar state of things is also to be seen in the deltas of the Volturno and Ombrene. As to the forces at work to bring about the present-day conditions, Dr. D'Arrigo refers to the recent attempt by De Marchi to explain the wearing away of the Adriatic coast near the mouth of the Piave, by a change of climate bringing with it a greater prevalence of southerly winds (see *Journal*, vol. 79, p. 201); and he considers whether the records point to a similar change which might have affected the Tiber delta. But the results are inconclusive. On the other hand a study of the existing régime of the winds in the Tyrrhenian Sea shows that the most prevalent is that from the south-east, and that, with the existing form of the delta and the exposures of its several parts, it is the tidal current from this direction which would be most effective in producing the observed corrosion. The paper is accompanied by detailed charts showing the changes within recent years.

DEAD RIVERS OF SOUTH AUSTRALIA

Professor W. Howchin has published a further instalment of his research into the evolution of the South Australian drainage system (*Trans. R. Soc. of S. Australia*, vol. 55 (1931), pp. 113–135). The Macdonnell Ranges for long periods have formed the main watershed of the southern portion of the continent, with consequent rivers flowing south, at right angles to the worn-down ridges. This hydrographic system is characterized by a combination of mature (grading of beds, absence of waterfalls, etc.) with juvenile features (*e.g.* deeply cut gorges). He shows how the older "trunk" stream flowed along the Fink River, through Chamber's Creek (now reversed) and Lake Torrens to the sea at the head of Spencer Gulf. During the Pleistocene, a new coastal watershed was developed, as a result of extensive plateau elevation in South Australia. This took the form of a broad geanticline extending for 500 miles from Adelaide to Marree. In this area there is abundant evidence that the existing drainage system was markedly interfered with. This barrier has produced a lake system to the north, and an absence of rivers to the south. Its main physical features are antecedent to the present geographical cycle, and in relation to these the drainage system is discordant. Blind river channels occur on the raised barrier, occupied by deep alluvial deposits. In the present article, Professor Howchin examines in detail the western rivers of this group, and provides a sketch-map showing their probable courses before they were truncated. The main stream seems to have occupied, in a reverse direction, the present Willochra Creek, crossing the

present watershed near Murray Town, to have received an important tributary occupying part of the bed of the Broughton River, and to have entered the sea in Gulf St. Vincent. Another tributary may be traced from the Lake Frome region.

ICE AND ALPINE MORPHOLOGY

Professor E. J. Garwood's recent presidential address to the Geological Society on "Speculation and Research in Alpine Glaciology: an Historical Review" is a useful summary which brings the subject up to date with his own views (*Quart. J. Geol. Soc. London*, vol. 83, pt. 3, 1932). In the latter part of the nineteenth century there was high controversy among European geologists between those who advocated the excavating power of ice, including (to cite a few British names) Ramsay, Tyndall, and Geikie, and those who denied it, including Bonney, Lyell, and Murchison. With the turn of the present century the investigations of Penck and Davis caused the direct erosive power of ice to be generally admitted, and at the present day the main difference of opinion is concerned with the relative importance of glaciers and rivers in the formation of the Alpine valleys. That those however who had denied the capacity of ice to erode the valleys and lake basins had some case is shown by the opinion of Penck himself that four-fifths of the valley formation was the work of pre-glacial rivers, and the rest of glaciers. Professor Garwood's own view is that the work of downward erosion was chiefly effected by the rivers during the interglacial periods discovered by Penck, while the valleys so deepened were widened, modified, and, to some extent, further deepened during the succeeding glacial periods.

Some of those, including Mr. Freshfield, who denied the erosive power of ice, emphasized its importance as a protective agent in the formation of Alpine scenery, and Professor Garwood concludes his address with a consideration of this subject. He considers that in certain circumstances ice may delay erosion by protecting the surface below from the action of other denuding agents, and the features which he attributes more especially to this protective action are the arêtes, cirques, valley steps, and in part the hanging valleys. In the case of the cirques and arêtes the depressions have been so protected while the walls have been steepened by frost action. He cites also the contrast between the steep southern slope of the main range of the Alps where the streams are cutting back into the divide, and the northern slopes which are relatively protected by huge snowfields and large glaciers. The paper ends with a quotation from the late Professor Gregory's 'Nature and Origin of Fjords,' which sums up the problem of glacial erosion thus: "There is no doubt glaciers sometimes act as agents of erosion and that under certain conditions their influence must be to some extent protective. The difficulty is in estimating the relative effect of these two processes." This is another striking illustration of the principle that in practically every scientific controversy the truth turns out to lie between extreme views which would never have been held if terms had been more strictly defined.

PHOTOGRAMMETRIC EQUIPMENT OF THE GRAF ZEPPELIN

We have received an interesting reprint from *Bildmessung und Luftbildwesen* of an article by Dr. von Gruber, "Über die photogrammetrische Ausrüsting des *Graf Zepplin* auf der Arktisfahrt 1931."

During this flight to the Arctic an attempt was made to obtain as much topographic data as possible of the hitherto unsurveyed regions visited. For this purpose the photographic method naturally suggested itself and an organization was evolved which included several of the latest developments of photogrammetric equipment. The methods adopted were based upon the Panorama-camera of Aschenbrenner and the Zeiss Double Camera. The former consists of nine

lenses working through prisms, and, in conjunction with a special rectifying printing apparatus, produces the equivalent of a photograph taken with a very wide-angled lens. The latter is formed essentially by joining two ordinary cameras together so that they possess a small common field. The results obtained with this equipment were remarkably encouraging and exceeded expectation. It is not stated how much actual mapping has been completed, but the general lines on which the problem has been tackled are indicated below.

The normal methods of plotting such photographs entail a large number of points previously surveyed on the ground and clearly identified on the pictures. In this case however no such data were of course available, and various ingenious approximations had to be made. The problem is essentially that of finding the position of each air station in space and the direction in which the camera was pointing at exposure. The air stations may be found in plan from a knowledge of the speed and direction of flight of the airship and the time interval from or to astronomical fixes. Their height may be obtained from altimeter readings. A check on the distances between air stations is given by the plotted positions of successive images of the shadow of the airship on the ground. The azimuth of the camera axis is available from the angle it makes with the airship's course, or from the shadow of the airship on the ground or the reflection of the sun in water, which latter considerations may also be used to obtain the dip, though this may usually be obtained more easily by photographing the horizon. Final resort may sometimes have to be made to the fact that water must flow downhill. By means of these and other approximate devices valuable maps may be constructed. The experience gained indicates that the equipment on any future flight should consist of a battery of cameras which effectively cover the complete transverse angular field, *i.e.* from one horizon through the nadir to the other horizon, and with which strips of overlapping photographs may be taken continuously. Every object within range of vision would thus be photographed.

Examination of the stereoscopic pictures obtained on such a flight indicates the extreme value of photography. Careful and leisurely examination may be made of topographic forms which, owing to the speed of the aircraft, could be scarcely appreciated by the naked eye at the time of exposure. The results add to the knowledge both of physical geography and geology. Information regarding currents may be obtained from the movements of ice-floes on successive photographs, and similarly the recorded movements and shapes of clouds may assist the meteorologist.

The work carried out in this flight is an excellent example of an opportunity seized and profited by. The same kind of result might often be obtained on the trails of aviators across the British Empire. The greater part of it is virtually unmapped and photographs of almost any kind would add to knowledge. The lightness and compactness of modern photographic equipment render the instalment of automatic film cameras in commercial aircraft a practical possibility, and it is to be hoped that in the near future the great opportunities thus afforded will have been taken. J. S. A. S.

THE MAPS OF EDINBURGH

Few cities can boast of so careful and comprehensive a catalogue of their maps and plans, from early to modern times, as that provided for Edinburgh by the labours of the late Mr. William Cowan, supplemented and brought up to date by Mr. C. B. Boog Watson. The first edition, by Mr. Cowan alone, was printed in 1923, in 'The Book of the Old Edinburgh Club,' vol. 12, under the title "The Maps of Edinburgh 1544–1851." This enumerated 53 plans, but could not claim to be thoroughly complete, while no indication was given of the libraries or other

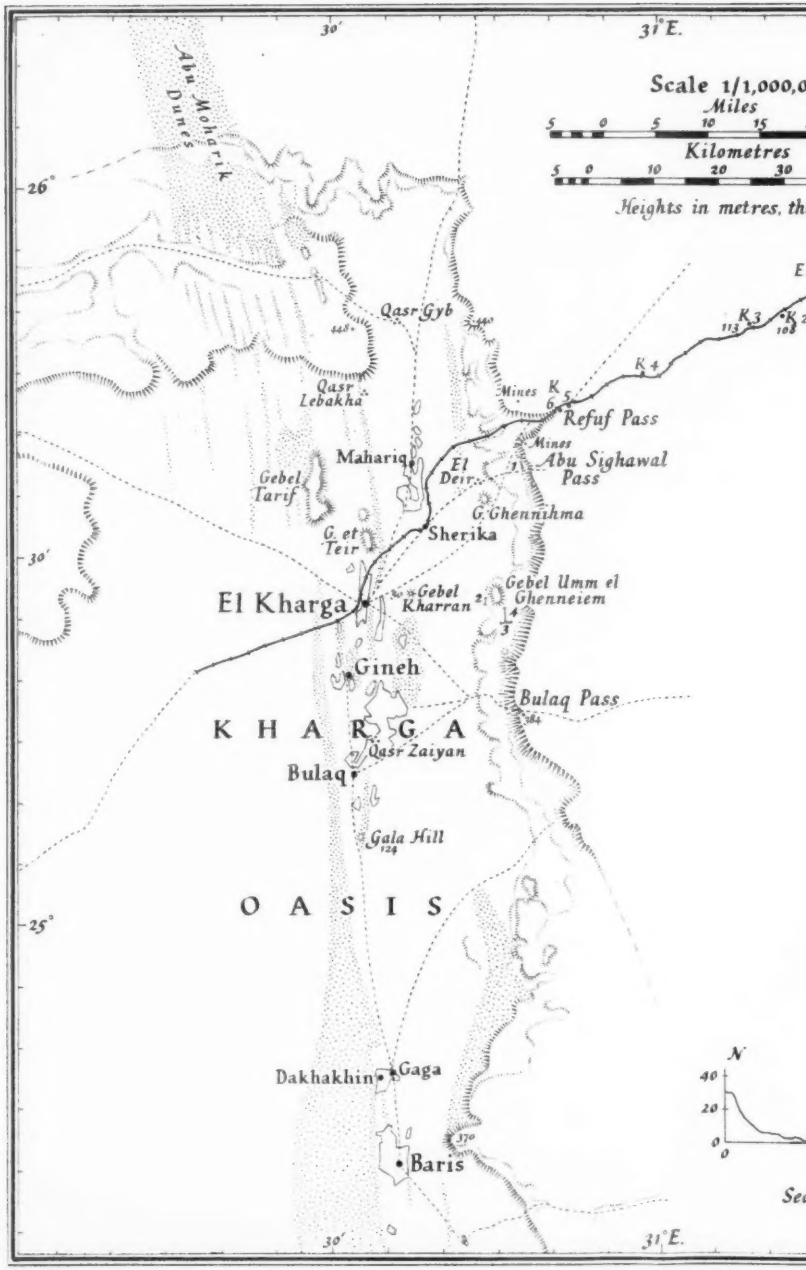
collections in which the plans are preserved. The Committee of the Edinburgh Public Library therefore decided, with the permission of the Old Edinburgh Club, to reissue Mr. Cowan's list and notes with additional matter to bring them as near completeness as is at the moment possible, and the task has been efficiently carried out by Mr. Boog Watson. The work bears the imprint of the Edinburgh Public Libraries, 1932, and is now entitled 'The Maps of Edinburgh 1544–1929.' The additions made to the original catalogue by Mr. Boog Watson are shown in square brackets, and bear witness to the care and research given by him to the subject. Particularly valuable are the references to the Edinburgh Collections, nine in all, in which the maps listed are to be found. One might have wished it had been possible to state also which of them are to be seen in the British Museum, but as the work is primarily of interest to residents in Edinburgh, this could perhaps hardly be expected.

It is impossible to refer in detail to the contents of the catalogue, which begins with more or less rough bird's-eye views, like that given by Braun and Hogenberg, *c.* 1581, and passes through earlier plans such as that of Gordon of Rothiemay, or the more accurate and elaborate productions of Edgar (1742), Ainslie (1780), Kincaid (1784), to those of modern times. Of William Edgar, about whom little is known, Mr. Watson has been able to bring together some details. Besides plans of the city as a whole the list includes many of special areas or aspects, and, for the eighteenth and nineteenth centuries, plans issued with directories and guides. Care is taken to list reissues of the same plan, and we can note how, here as elsewhere, a plan once made had a life of perhaps well over a century. An instance (which does not stand alone) of recourse to Dutch engravers for the actual production of British maps is given by Gordon's map of 1647, produced by De Wit in Amsterdam. The want of an alphabetical index is in part made up for by a concise chronological index.

It should be recalled that the recent interest in the subject has been largely due, first to the exhibition of early maps of Edinburgh organized in 1919 in the rooms of the Royal Scottish Geographical Society, and afterwards to the issue by that Society of a special Edinburgh number, in which, besides a sketch of the history of Edinburgh mapping by Messrs. William Cowan and H. R. G. Inglis, a number of the maps and views were reproduced.

AN EARLY ITALIAN TRAVELLER IN RUSSIA

In the history of trade relations between Europe and Asia, Paolo Centurione is known for his idea of circumventing the Portuguese monopoly by a route through the Baltic and Russia to India. Centurione, a Genoese, paid two visits to Moscow, in 1520 and 1524, but was unable to gain the support of the Grand Duke. He is said to have visited England in 1525 to advocate the development of the north-east sea passage to Russia, a project not carried out for nearly thirty years. The sources for our knowledge of Centurione have been the 'Lettere della cose di Moscovia, 1525,' by Paulo Jovio (printed later by Ramusio), and the researches of the Abbé Pierling. In the *Bollettino* of the Royal Italian Geographical Society for May–June 1932, Signora Maria Modigliani draws attention to another source. A "Discorso della Moscovia" is to be found in the Vatican archives, and has been reprinted by A. J. Turgenev, who erroneously attributed it to Marco Foscarini. The writer shows that this account and that of Paulo Jovio are based upon a common source, very probably written by Centurione. The anonymous account is the more detailed, and shows that Centurione was particularly careful to gather as much information about the Tatars as possible. The route proposed lay through the valleys of the Indus and Oxus to the Caspian, thence *via* the Volga to Moscow and Riga.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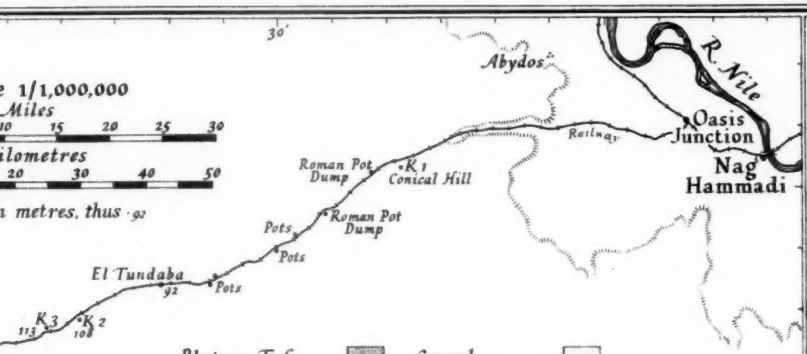
No. 1

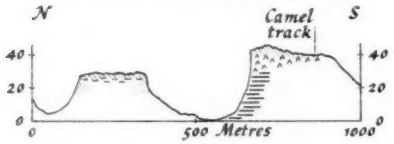
Maps and Sections showing Tufas and Gravels of east sca



Plateau Tufa
Wadi Tufa
Silt
Shale
Limestone & Marl
Eocene & Cretaceous
Gravel
Breccia
Cultivated areas
Tracks

Vertical scale of sections exaggerated 5 times

Section 1. Abu Sighawal Pass



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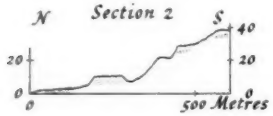

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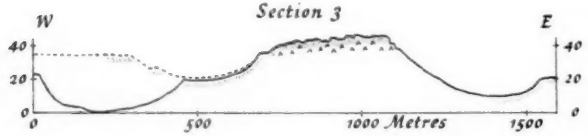

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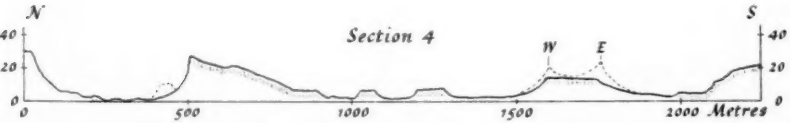

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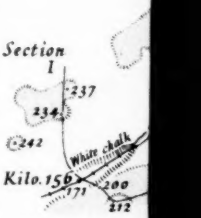

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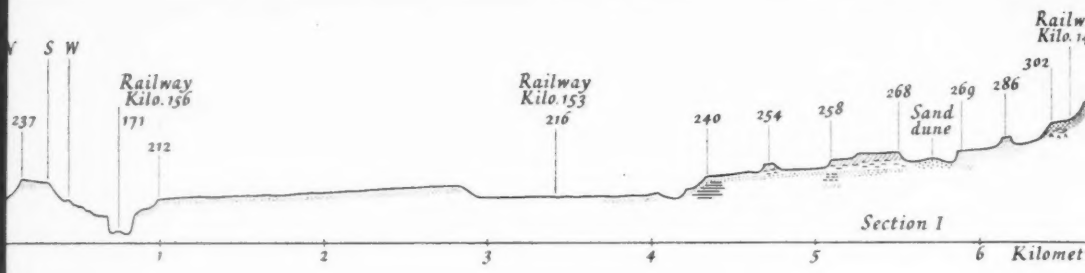
Published by the Royal Geographical Soc



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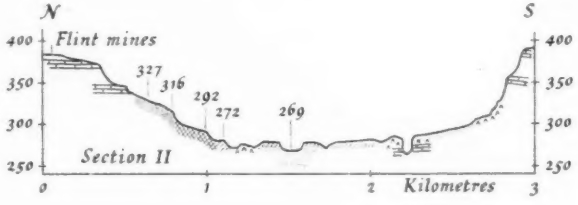

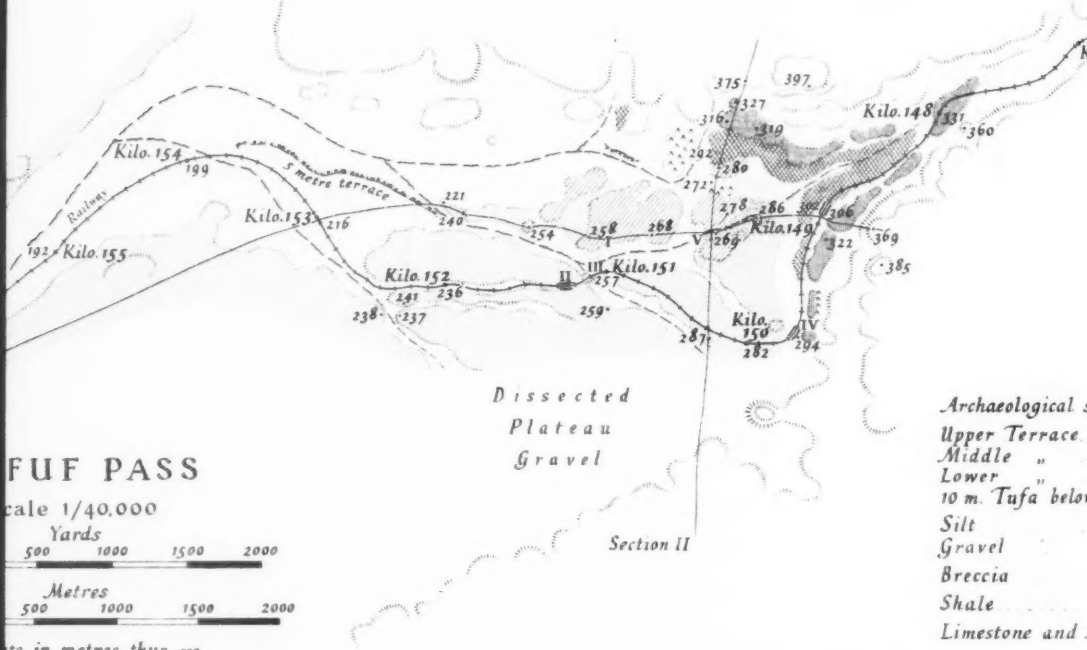

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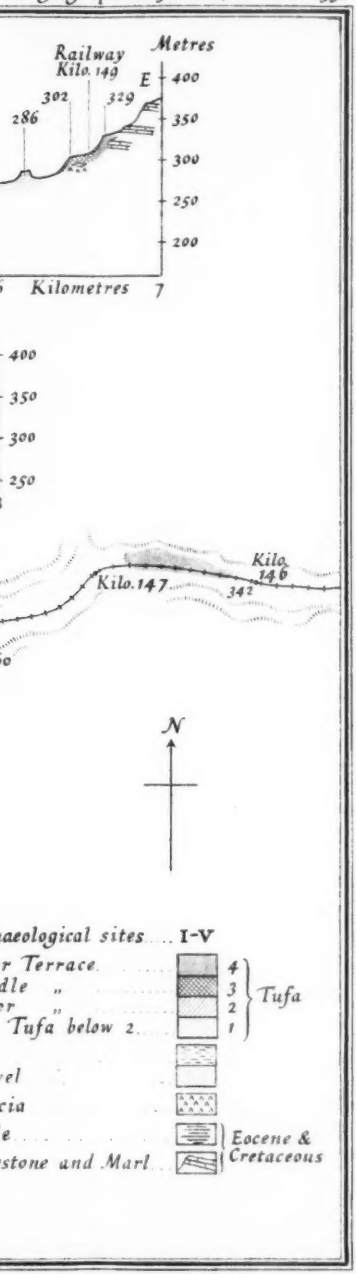
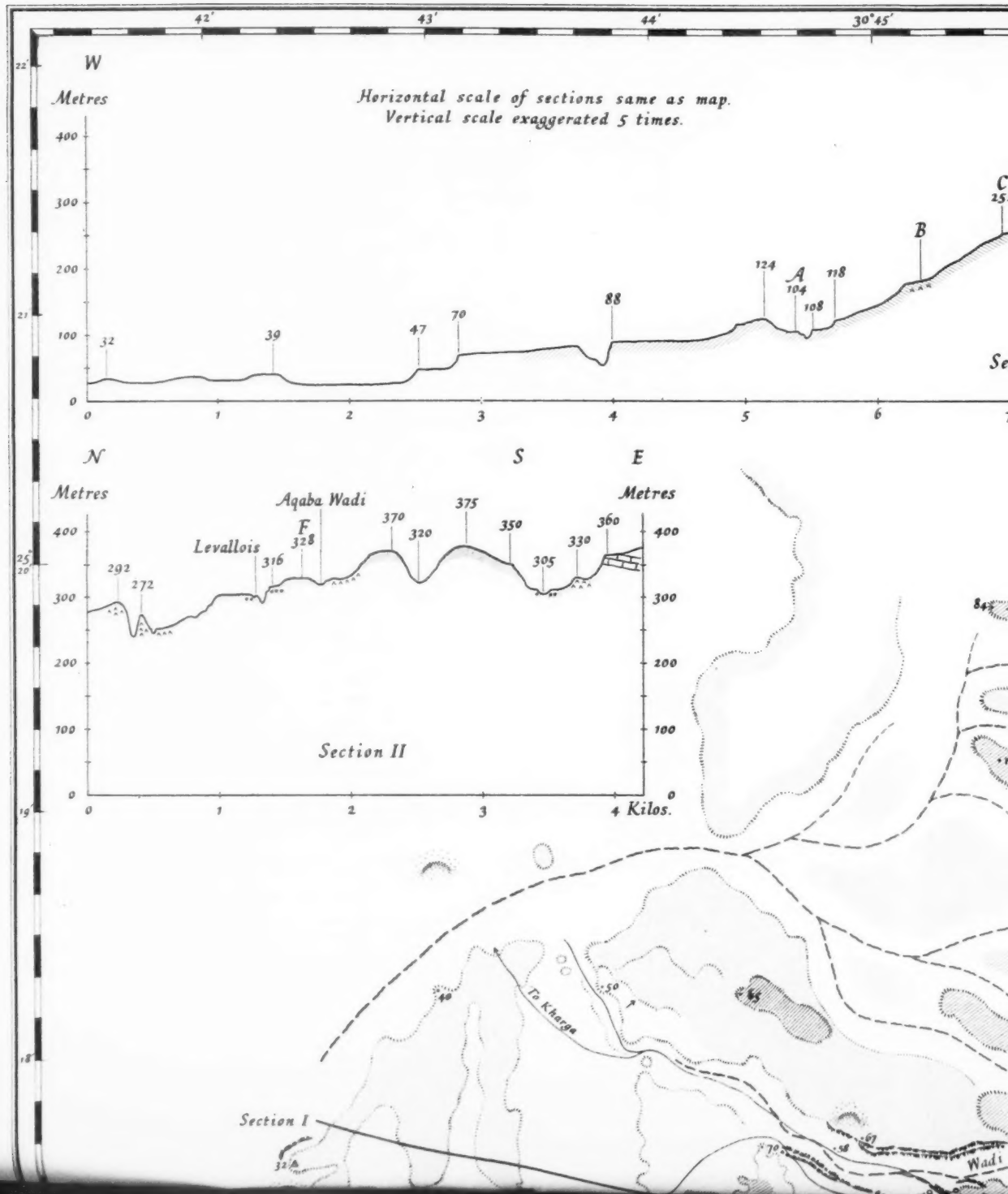


KHARGA OASIS
Caton-Thompson and Gardner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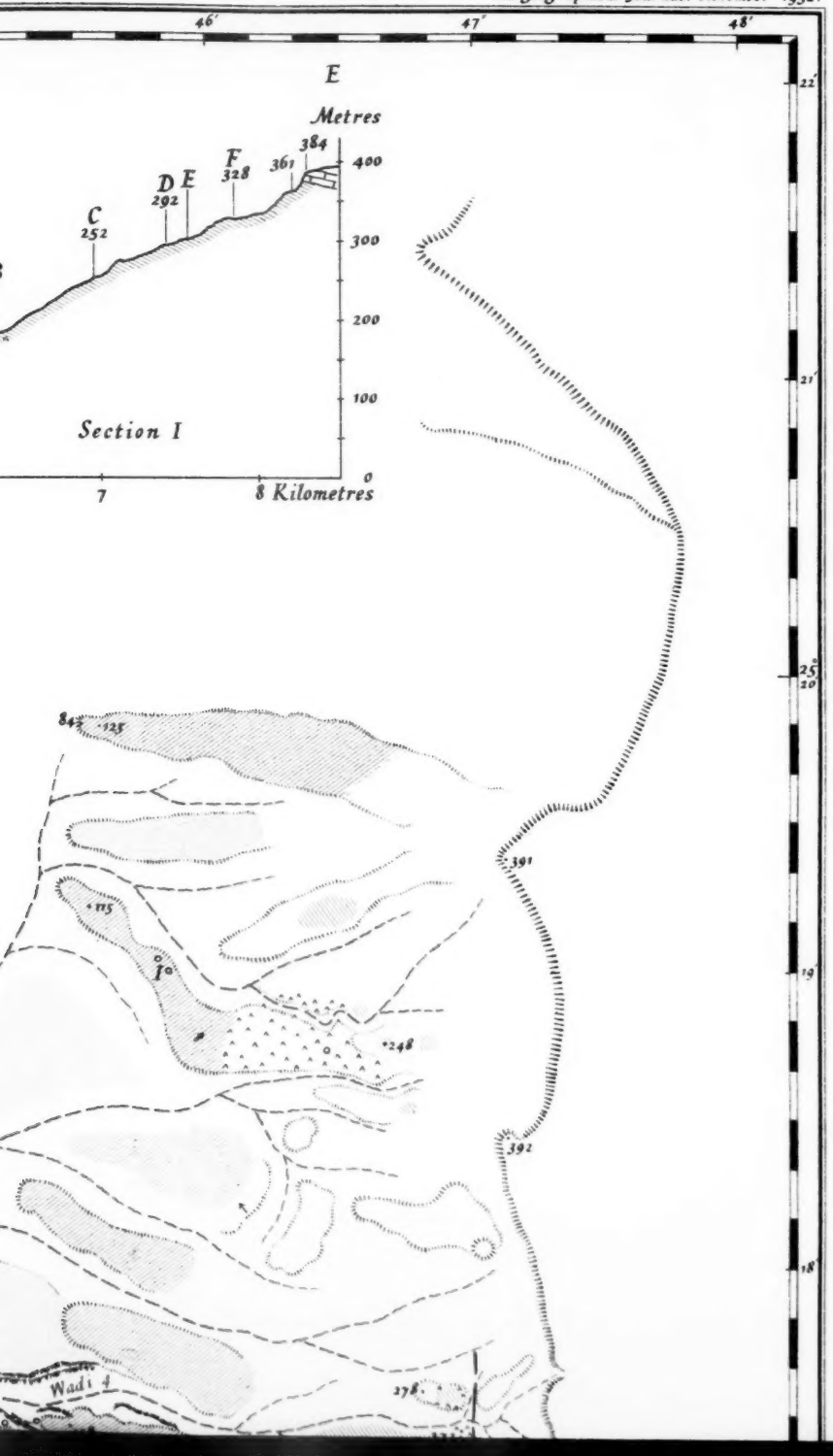
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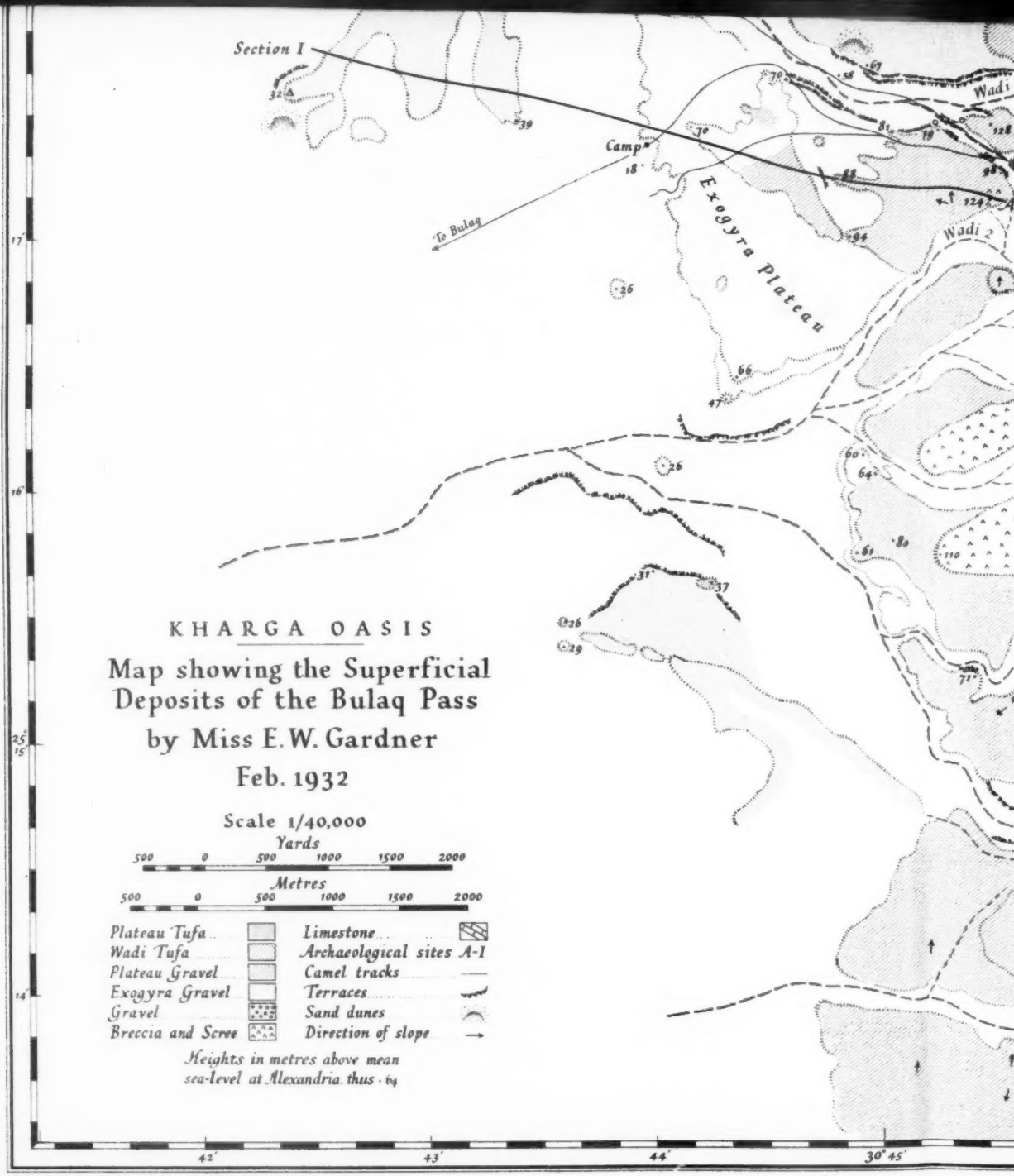

KHARGA OASIS

Map showing the Superficial Deposits of the Bulaq Pass

by Miss E. W. Gardner

Feb. 1932

Scale 1/40,000

Yards 500 0 500 1000 1500 2000

Metres 500 0 500 1000 1500 2000

Plateau Tufa	Limestone
Wadi Tufa	Archaeological sites A-I
Plateau Gravel	Camel tracks
Exogyra Gravel	Terraces
Gravel	Sand dunes
Breccia and Scree	Direction of slope

Heights in metres above mean sea-level at Alexandria thus · 64

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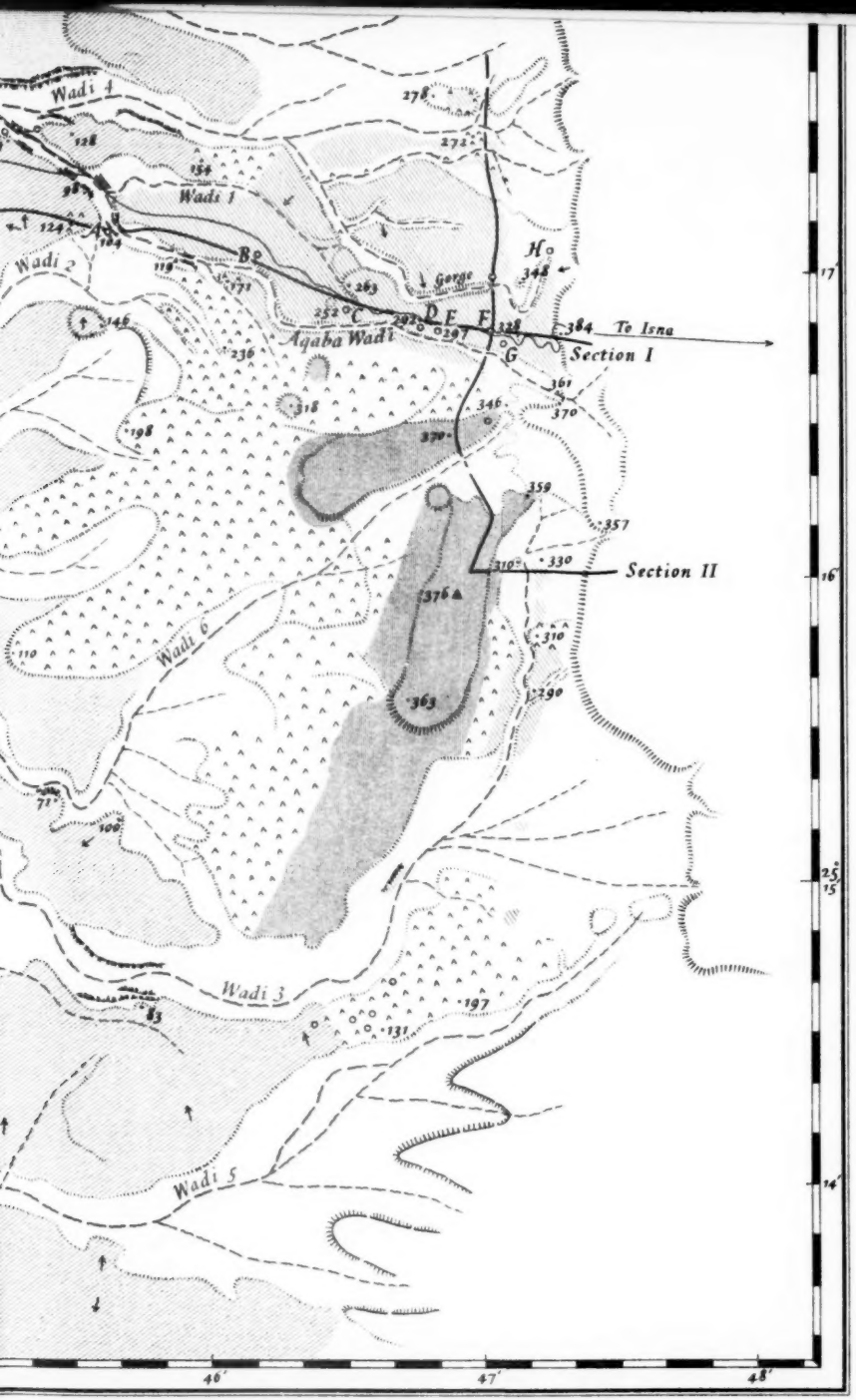
No. 3



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